THE DEVELOPMENT OF CREATION ON THE EARTH.



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BY

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LONDON.

TRÜBNER & CO., 57 AND 59 LUDGATE HILL.

1874.

"Does the Lord of Truth Himself speak to us, even in these discoveries, or suggestions of scientific research, and is He calling upon us, and inviting us, in them, to abandon, or to alter and qualify, our ancient and long-descended ideas by these new revelations of His infinite activity in the ages of the past?"—*G. Vance Smith in the Contemporary Review for April* 1874.

PREFACE.

THE phenomena of nature, to which the following pages relate, cannot present themselves to any thinking mind without claiming from it some solution. Hitherto we have been accustomed to suppose that we had before us, in an inspired record, a reliable account, in outline, of this earth's history, exhibiting to us the manner in which all things we observe were put into shape, or called into being, and the time when this was effected; but as knowledge has advanced, the Biblical representations have become exposed as untenable, so that with most instructed persons it has become a necessity to frame, upon the ascertained facts, some surer ideal of the mode in which the creative processes have been carried out, and to form some conception of the true probable periods involved in bringing them to their present stage of development.

On certain points, all who have any measure of knowledge on these subjects may be said to be agreed. The method has not been by sudden magical demonstrations of power, in so many distinct successive acts. Human delineators are apt to seek, by scenic representations, to attract attention to alleged direct divine agency. Such is not the character of true creative power, which moves silently, majestically, and unerringly, with no hurried

action or spasmodic effort, to its appointed ends. Through well-ordered systems, in use of natural means, simple yet grand in the magnitude of their results; without limits of time or stint of applied forces; slowly, gradually, but inevitably, from some early primitive stage, through a long series of methodized operations, we see accomplished, works planned with consummate design, and executed with unfailing skill. We have to consider the architect who exhibits himself in these stupendous undertakings. The means and channels through which the work is effected and maintained, are the known properties and susceptibilities of the materials used, brought into endless combinations. Nothing moves but in a law-directed course. All yields implicit obedience to the governance appointed to it. Some of the materials are readily discernible in their tangible solidity. Others more or less evade analysis and observation, such as the gaseous bodies, and heat, light, and magnetism; and these are the most active and most powerful in their agency. Each atom has its uses and adaptibilities, and takes its place, and performs its part, in never-resting action, realizing the required adaptations for the composition of specific and closely allied forms. Nothing has independent existence or isolated aim. The power that moves the whole does not prosecute these labours by convulsive starts, nor is it ever exhausted. Creation knows no pause. It is always consistent with itself. What has been, is, and ever will be. We stand as inquiring observers in the midst of this unceasing work. We have not to contemplate the pictorial exhibition of an accomplished task. We are in the presence of a living artist continually displaying his resources, project-

ing what is illimitable, and unfathomable, holding us floating in the midst of an eternally expanding creation. The scenic view suits the sentiments of an uninstructed mind, and was devised in days of unavoidable ignorance. The comprehension of the well-ordered, truly-balanced, never-ending correlation of forces, with their perpetually diversified results, feeds the apprehensions of those who have better discernment. The imaginary representation dwarfs and debases the understanding; the true study nourishes and exalts the sentient being in the contemplation of the march of courses that are interminable. The recipient of the legendary statement is as one who has made his little fortune and invested it, neither discreetly nor profitably; the student of nature is in the midst of boundless wealth multiplying itself in unceasing and ever-varying fresh developments."

Our privilege is to contemplate and to endeavour to understand these great operations through the imperishable records they have left behind them. The earth, as it has often been observed, is laid out like a well-ordered cabinet, presenting to us, in measure, some means of judging how the laws of nature and the essential properties of matter have worked out all we see before us. That there have been depositions of strata, gradually laid down, and stocked with the remains of the living objects, vegetal and animal, that flourished when they were being imposed, is an universally acknowledged fact. It speaks of a constantly maintained series of operations whereby the globe has been brought to its present condition, and which are ever advancing it to stages that are still before it. That immeasurable ages have been consumed in effecting these developments is

also conceded. We witness the very graduated rate of the existing advances, and can see that the past action must have been conducted in the same slow, deliberate manner. For a time a stand was made in favour of the modern history assigned in the Biblical representations to the human race, but now all who have made the study, in view of the remains he has left behind him, and their position in the shelves of the earth's cabinet, are satisfied that to man also belongs some indefinable antiquity.

But there are other questions on which inquirers are not agreed, and which therefore still lie within the domains of fair discussion; and unless I had had something to offer on these heads, I should have indulged in no representations of what is so currently accepted. The conditions of my argument have made it necessary that the known landmarks should be properly understood and worked upon; nor could the Biblical statements, on which in other works I have been occupied, have been properly passed by without exhibiting what we know of the actual processes of creation. The doctrine of evolution, that is the production of settled organized forms out of shapeless matter, is one very generally received; but it is coupled, by a certain class of students of nature, with the suggestion that one shape has grown out of another. Is there no better conception of the process to be formed than this, resting upon less hypothetical reasonings? The theory that every living object has been produced from an antecedent germ, which is true in the generality of current instances, is sought to be applied to all. But the allegation meets with an insuperable difficulty, still to be solved, when we go back in thought to the

primeval germ producer. In what manner did this object come into being, having no germ before it from whence to issue? How the Infusoria are formed is a great question on which naturalists are far from agreed. Do they spring from imperceptible germs, or are they constituted, primitively, out of surrounding materials? If produced in this latter manner, do they possibly afford a rule for the primitive formation of the superior classes of animated objects? In what way have the different regions of the globe, however isolated, been stocked with appropriate products, vegetal and animal? What has led to those great climatic changes, whereby the same portions of the earth have had at various times climates that were glacial, temperate, and tropical? What causes the constant contortions and dislocations of strata, and the upheaval and depression of land levels? Above all, from what ultimate power do all these great and diversified operations witnessed by us proceed? Are the laws which effectuate them all sufficient to that end? or is there behind and beyond these laws some supreme designer and operator who through them is working out all things to the accomplishment of pre-determined ends?

The solutions I have ventured to offer on these important questions are based, as carefully as I have been able to maintain myself, upon observed results. In studying nature we fall into inevitable peril directly we begin to build upon anything but her own exhibited ways. My rule has been to assume that the methods by which traceable phenomena have been effected, are those by which strictly corresponding phenomena, whose actual processes of elimination are not disclosed to us, have

been brought about. It is the lesson currently followed in judging of the stratified formations of the crust of the earth, and the domination of the known forces which act upon all things of which we are cognizant. What is wrought in one way in present times, has been, we conclude, the manner in which similar things have been wrought in past times. To assert any other course is to assume a knowledge without data on which to found it, and is in effect a mere indulgence of the imagination. Much, no doubt, is to be gained only upon deduction, but then the stepping-stones on which we make our advances should be ascertained and sure. With such certainties I have to the best of my ability armed myself, in the endeavour to fathom the great mysteries which offer themselves to us for our study and comprehension.

GREAT MALVERN, *May* 1874.

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POSTSCRIPT.

I.

THE PROCESSES OF CREATION.

A COMMON idea of creation is that it is the production of something out of nothing. But of any such operation we have no experience. Whatever is brought under our observation has been formed from some prior existing material. It is, therefore, a contradiction of our senses to suppose that anything has been called into being having a thoroughly independent origin. The ancients believed in the eternity of matter, and it is impossible to present to our minds a condition existing devoid of matter associated with it. There are postulates for which the human mind is incapable of conceiving a solution. If the idea of a self-existent deity may be entertained, that is one. There can have been no time when he was not, and then came into being, and yet we are wholly unable to compass the idea of one in existence who has never had a beginning. It is the same as to infinitude of space and eternity of time. There can be no confines to space beyond which there is no space, or any degree of remoteness of time beyond which there was no time; and yet the constitution of our minds, exercised ever over what has limits, cannot realize the idea of anything existing without limits. And it is thus as to the eternity of matter. If eternity attaches to space, as is necessarily the case, then we cannot conceive that such space can ever have existed void of material contents. It is impossible, it has been well observed, to place before our imaginations the conception of "nothing." If, then, there must have been something to express and occupy the space, we have before us the necessity for an eternity of matter, equally as for an eternity of time and space. In keeping with this condition is the non-destructibility of matter. It is decomposed and passes into other forms, but is never obliterated from absolute being.

But while it must be true that matter has always existed, its various combinations and presented forms certainly denote operations which have had sensible beginnings. The globe we inhabit is such an object. It is suggested that it may have been thrown off from the nucleus of the sun in gaseous condition, and has gradually cooled down and become solidified. This may have been so, but my purpose will be sufficiently met by dealing with the earth from the time when it was constituted in form such as is presented to the senses.

We find the earth laid out in various strata, containing in a fossilized condition the remains of the organic objects which have occupied its various successive surfaces, the whole being super-imposed on unstratified rock, void of such organic remains, which must have constituted its original crust. The earliest fossils are invariably of marine origin (Frith, *Thoughts and Meditations on the Mysteries of Life,* 36, 200), whereby we may conclude that at the outset the earth consisted of its granitic crust, submerged in water. The primitive rock was destitute of the constituents of life. It was wanting in carbon, sulphur, and phosphorus, which are necessary elements, and was everywhere covered by a vast ocean, in the depths of which, in the process of time, those changes were wrought which eliminated life (Frith, 197-200).

The granitic crust would be subject to those volcanic disturbances that must have ever prevailed. There would be upheavals from below, and gases bursting through with molten matter, which would be ejected on its surface. The broken portions would undergo attrition in the waters prevailing over them, and in time become decomposed, and recomposed with surrounding elements. First, would be deposited those layers of schist and clay slate, observable on the granite, which are chemically like the granite, and therefore devoid of all signs of life (Frith, 197). The process of dissolution and deposition advanced; and as the materials became more and more mobile, and rose to higher levels, they became susceptible of admitting into their composition other ingredients, prominently what could be received of the hydrogen and oxygen belonging to the surrounding water, and the carbon, oxygen, hydrogen, and nitrogen derivable from the inter-penetrating atmosphere. For example, in the Bala limestone, which belongs to the

lower Silurian system, are the first traces of that necessary constituent of life, carbon (Frith, 197). In the Silurian rocks accordingly are found the earliest evidences of life on the globe, which appear in the shape of algæ, or marine plants, corals, sponge-like substances, small sea-shells, worm-like forms, and a well organized small crustacean, termed the Trilobite (Frith, 36). As the system progressed, there are shown to have been further developments of marine plants, zoophytes, radiata, mollusca, and crustaceans, until at length, in the upper strata of these deposits, are fishes (Frith, 200). To this time no land organisms appear; all life, whether vegetal or animal, was of marine origin (Frith, 200). We now pass into superior strata, termed the Devonian, or Old Red Sandstone. The marine products were continued, but with considerable variation; and there are also here evidences of terrestrial flora, in the shape of marsh plants, reeds, rushes, and fern-like plants (Frith, 36; Page, *Past and Present Life on the Globe*, 92). The detritus laid at the bottom of the universal ocean has accumulated, the volcanic upheavals have been adding more and more of fresh materials brought up from the inner cavities of the earth, the gases from the water and the air have been continually added thereto, vegetable and animal forms have been produced, and have multiplied, and their decay and decomposition have supplied further materials for the elimination of new forms. Gradually the depths of the ocean have been reduced by the depositions laid upon its primeval bed; and, with the aid of upheavals from below, the land has in places at length asserted itself above the level of the waters.

"The thickness of the crust of the earth has evidently been continually increasing. The stratified rocks are not composed altogether of waste derived from previously existing rocks, but throughout the whole process newly solidified matter, derived chiefly from the waters of the ocean, but also to some extent from the atmosphere, has mingled with the *débris* derived from the wear and tear of older rocks" (Frith, 234, 235).

"Instead of the surface of the earth being that stable, fixed thing, that it is popularly believed to be—being, in common parlance, the very emblem of fixity itself—it is incessantly moving, and is, in fact, as unstable as the surface of the sea,

except that its undulations are infinitely slower, and enormously higher and deeper" (Huxley, *Lectures to Working Men*, 34).

Mr Darwin gives numerous instances, met with by him in his travels, of extensive elevation and subsidence of land, illustrating "the never-ceasing mutability of the crust of this our world." The earth, he observes, "the type of solidity, has oscillated like a thin crust beneath our feet" (*Voyage of the Beagle*, III. 569, 606).

The movements here spoken of are so widely extended, graduated, and constant, that it is apparent they are due to some other cause than the violent irregular action of the explosive gases which burst from the interior of the earth, and produce earthquakes and volcanoes. But however caused, this fluctuation in the surfaces of the earth must have promoted the alteration in the conditions of its crust which has led to the generation thereupon of organic objects endowed with life.

With the establishment of dry land, we enter upon a new phase in the creation. A vast accession of productive power is obtained when the surfaces to be acted upon, freed of the obstructive medium of the waters, are exposed to the full influence of the solar rays, imparting light, heat, and magnetism, and to the atmosphere, with its gases and decomposed substances, ever ready, under the powerful stimulus of the sun's forces, to enter into fresh combinations. A period of prolific growth of vegetation ensued, and introduced the carboniferous era. In the vegetable kingdom we have club mosses, ferns, tree-ferns, conifers, and palms, often of gigantic dimensions; and in the animal, insects, reptiles, wingless birds, marsupials, and fish of a higher type than before existed (Frith, 37). The coal deposits are of vast extent, and have been formed of submerged forests, solidified into mineral compost. Similar processes are continuously going on. Peat bogs are of this character, being vegetable deposits in course of being mineralized. Successive growths of forest, one rising upon the *débris* of the other, have occurred. In Denmark, a forest of pine has, after flourishing and decaying, been succeeded by one of oak, which, in like manner, has been replaced by one of beeches (Lubbock, *Pre-historic Times*, 196). In the Delta of the Mississippi a growth of aquatic plants has been followed by forests of cypress, of which ten in succession have been observed;

and over all now is one of live oaks (*Types of Mankind*, 337, 338). Herbs and trees everywhere, as they cast off their leaves and refuse parts, create upon the subsoil vegetable mould, often of considerable depth, and forming food for fresh fertility.

"The course of vitality is thus for ever onward and upward—onward in the introduction of forms having more varied geographical adaptations, and upward in the manifestation of higher physiological and functional performance. . . . If there is one truth that geology has established more clearly than another, it is that of the progressive evolution of life on this globe—not progress from imperfection to perfection, for all are alike fitted to the end for which they were created, but progress from simpler to more specialized forms. All the discoveries that have been made, and are daily making, never controvert in the least this great order of life; nor do the ablest geologists, though anticipating many new forms, ever expect to find it otherwise with creation than onward and still upward" (Page, *Life on the Globe*, 111-113).

"Life begins at the base, or near the base, of the stratified rocks. Vegetable life commences with fungi, and animal life with globular cells, corals, and jelly fish. Each succeeding age has added to these humble forms of life some organ, some limb, some function, some sense, which was not possessed by their predecessors; so that there has been a gradual development of function, accompanied by increased energy of life and beauty of form" (Frith, 236, 237).

The chalk deposits, which are of great extent, exhibit the powers that can be exercised in the generation of life at great depths, at the bottom of the ocean, and thus illustrate the operations in eliminating life when all such process had to be carried on upon surfaces buried under the universal Silurian waters. The chalk to be found in Europe, North Africa, Syria, and the Crimea, if all laid together, would form an irregular space of about 3000 miles in its widest diameter. In some places in England it reaches a thickness of 1000 feet. When examined under a microscope, it will be found "made up of very minute granules; but, imbedded in this matrix, are innumerable bodies, some smaller and some larger, but, on a rough average, not more than a hundredth of an inch in

diameter, having a well-defined shape and structure. A cubic inch of some specimens of chalk may contain hundreds of thousands of these bodies, compacted together with incalculable millions of the granules." These rounded bodies are of various shapes, beautifully constructed, with inter-communicating chambers. In preparation for laying down the Atlantic cable, the ocean was carefully sounded, and its bottom examined for a space of 1700 miles, from Ireland to Newfoundland. Over a space measuring about 1000 miles, by a breadth of 600 or 700 miles, and at a depth in places of 10,000 feet, a fine chalky mud was found in process of deposition, consisting entirely of the hard parts of minute animals, which in time become solidified into chalky limestone, leading thus to the certain conclusion "that the chalk is the mud of an ancient sea bottom" (Huxley, *Lay Sermons*, 175-191; also, *Lectures to Working Men*, 43). The explorations of the sea-beds have been prosecuted with important results. "Dredges, weighing with their load of mud nearly half-a-ton, have been hauled up without a hitch from depths of some 14,000 feet." And these "deep-sea dredgings have proved that not only does life exist in the very deepest parts of the Atlantic, but that beings which live, and move, and have their being beneath the three-mile mountain of water, have eyes which the ablest naturalists pronounce to be perfectly developed. Light, then, of some sort, must exist in those abysms" (Proctor, *Light Science for Leisure Hours*, 146, 147).

The labours of the coral insects also show the prolific powers which are exercised under the surface of the sea. "Nothing can be more impressive than the manner in which these diminutive creatures carry out their stupendous undertakings. Commencing from a depth of 1000 or 1500 feet, they work upwards in a perpendicular direction, and, on arriving at the surface, form a crescent, presenting the back of the arch in that direction from which storms and winds generally proceed, by which means the wall protects the busy millions at work beneath and within" (Hogg, *On the Microscope*, 236). "They rear from the ocean-bed vast craggy terraces, hundreds of miles in length" (Milton, *Stream of Life on the Globe*, 39). "Such coral reefs cover many thousand square miles in the Pacific and in the Indian oceans. There is one reef, or rather great

series of reefs, called the Barrier Reef, which stretches almost continuously for more than 1100 miles off the east coast of Australia. Multitudes of the islands in the Pacific are either reefs themselves, or are surrounded by reefs. The Red Sea is in many parts almost a maze of such reefs; and they abound no less in the West Indies, along the coast of Florida, and even as far north as the Bahama Islands" (Huxley, *Critiques and Addresses*, 118). The coral insects cannot live at a depth exceeding about twenty-five fathoms. At lower depths nothing but dead coral is brought up. There are formations stretching for 1000 miles or more, having a depth of 2000 feet or more below the surface of the sea, the solution presenting itself being that there has been a slow continuous rising of the sea level, with which the coral insects in their structures have kept pace (Ibid. 122-128).

Vegetable life is of facile occurrence, of nearly universal prevalence, and endowed with enormous reproductive powers. Wherever a surface of granite is abraded and disintegrated, lichens and mosses appear (*Approximations to Truth*, 12). Mosses can multiply themselves 200 or 300 times in a week. Rust, smut, mildew, mould, and all such blights on the surfaces of living plants, are due to myriads of microscopic fungi (Bastian, *The Beginnings of Life*, II. 338, App. lxv.). Supposing the dry land to be 51,000,000 of square miles, and all parts in contact together, and subject to the same climate, a plant occupying one square foot, from which fifty seeds germinated annually, would in nine years multiply itself so as to cover the whole space (Huxley, *Lectures to Working Men*, 122, 123). The author gives the figures leading to such result. Insect life is very prolific. All vegetation swarms with it; and it is life of short duration, continuously depositing its decomposed elements, to be as constantly renewed in fresh organizations. Infusoria swarm in all stagnant waters, and are evolved wherever moisture and heat are brought to bear upon decaying substances. Fish life is also very prolific, and is constantly increasing the animal deposits in rivers, lakes, and oceans.

The materials from which all organisms are produced are obtained more from the fluid and aerial elements than from the solid ingredients of the earth. The great agency is in the plant

tribes. They have the power of gathering their constituents from earth, air, and water, and creating from them organic matter. Carbon is their chief component; and this is collected from the atmosphere by their leaves, and taken up by their rootlets from rain water. All vegetation, including the great forest growths, is thus mainly obtained from the air; and when decayed, a certain portion of it solidifies into earth. Animals, as a rule, are powerless for the creation of organic matter. They replenish and build up their structures by feeding on vegetable growths, and assimilating the organic tissues which these have provided. By exhalation, excrementation, and final decay and decomposition, they give back to the atmosphere, in their primitive states, the gases entering into their composition, acquired from that source originally through the medium of the vegetable kingdom, leaving but a small residuum of what has constituted them to be deposited on the earth; so that plants and animals may be said to be *the offspring of the air* (Bastian, I. 131-136). In the flesh of adult mammalia water forms 68 to 71 per cent., organic substance from 24 to 28 per cent., and inorganic substance from 3 to 5 per cent.; and in the fœtal state the water amounts to 87 per cent., and the solid organic constituents to only 11 per cent. (Herbert Spencer, *Principles of Biology*, I. 125). The circumambient air is therefore the great storehouse from which the earth is stocked with inhabitants, vegetal and animal; and the solid crust of the globe is replenished and continuously added to by that portion of their materials, undispersed in gases, which is deposited upon it at their decay.

It becomes thus apparent that organic forms are put together out of surrounding elements by some power directing the combination. We see in nature unceasing chemical operations, ingredient brought to ingredient, fresh properties thereby evolved, further composition ensuing, higher power eliminated, until at length, all circumstances favouring, in some mysterious manner we have before us organisms endowed with life, and capable of repeating themselves *ad infinitum*. The first living element that is produced is termed protein, and the first form of life, whether in vegetation or animals, is cellular (Huxley, *Lectures to Working Men*, 26). The progressive growth is by a repetition of the cellular forms projected from the original

cell as the development advances. These alter in shape and position. Some unite together to form a tube; and others, by interposition of denser matter, become solid (Herbert Spencer, *Principles of Biology*, I. 140). The plant begins as a little seed. It soon draws into itself water, and carbonic acid from the air, and combines them into protein (Huxley, *Lectures to Working Men*, 4). The seed throws out shoots, from which leaves are expanded, till the whole structure is completed. The largest plants are made up of a combination of such units as constitute the smallest. A tree is but an assemblage of numerous united shoots, and a similar process of building up the form is traceable through a considerable part of the animal kingdom (Herbert Spencer, I. 109). Professor Huxley gives as an illustration the development of the embryo of a horse. At first it is a cell, or in effect an egg, which passes out of the ovary of the mare. This cell has a nucleus in its centre, surrounded by a clear space and by a viscid mass of protein. In time there appears upon its surface a little elevation, which becomes divided by a groove. Gradually from this groove a double tube is formed. In the upper and smaller tube the spinal marrow and brain are fashioned; in the lower, the alimentary canal and heart. Two pairs of buds shoot out at the sides of the body, which are the rudiments of the limbs. Gradually the whole body is formed in all its varied parts of muscle, gristle, bone, fibrous tissue, and hair (*Lectures to Working Men*, 18). The growth of a man, observes Mr Herbert Spencer, is similar to that of a shoot of a plant evolved from a bud. A little tongue-shaped projection buds out from the side of the embryo. This lengthens, and a pedicle is formed at its end, which flattens and divides into the fingers. Afterwards the elbow-joint is formed, and the limb is thus gradually completed. The rudimentary arm is at first a mass of cells. These fall into place, and become bones, muscles, blood vessels, and nerves (*Principles of Biology*, I. 140).

The human germ outwardly resembles the germs of all plants and animals, between which there are no apparent differences. Gradually it becomes distinguished as an animal germ, but is not different from those of all fishes, reptiles, birds, and mammals. Then it assumes the characters of a

mammal germ; of a placental mammal; of a placental ungulate or clawed mammal; of the quadrumana; and finally of the human species (Herbert Spencer, I. 142). There is a time, equally observes Professor Huxley, when the embryos of neither dog, nor horse, nor porpoise, nor monkey, nor man, can be distinguished by any essential feature from one another (*Lectures to Working Men*, 19).

The substance of which organized bodies, vegetal and animal, are formed, is termed colloid, in distinction from crystals, which belong to mineral formations. The colloid, or gluey substance, is elastic, pliable, and penetrable by liquid, while the crystal is hard and unyielding. But there is no impassable line between the two. For example, crystals are formed by blood pigments, and simple saline substances may pass into the colloidal condition (Bastian, *Beginnings of Life*, II. 39, 40). Where a viscid ingredient, such as a solution of gum, albumen, or glycerine, was introduced, forms have been obtained closely resembling the simplest organisms (Bastian, II. 60-63). Mr St George Mivart makes the bolder assertion that colloidal matter formed from crystalline matter, when exposed to certain conditions, presents the phenomena of life (*Genesis of Species*, 306). The passage of inorganic into organic matter, which as a fact is indisputable, becomes thus evidenced to the senses.

The process of crystallization is analogous to that of the building up of organized forms. Mr Crosse, by means of weak galvanic currents, obtained a long list of crystallized minerals similar to what hitherto had been only met with in mineral veins (Bastian, I. 238 ; II. 57). It is therefore by composition out of surrounding elements that these products occur.

In crystallization each salt separates from the solution only those molecules that are like itself. It is just so in the animal economy. Muscle, nerve, or bone, each selects from the general supplies of the blood its own proper constituent (Bastian, II. 78, 79). The form of the crystal varies, to some extent, according to the solvent from which it separates itself (Ibid. II. 58). The crystals of common salts from pure water are cubes; but if boracic acid is introduced, the cubes are truncated. Carbonate of copper, crystallizing from a solution containing sulphuric acid, forms hexagonal tubular prisms; but if a little ammonia is added, the form changes to that of

a long rectangular prism, with secondary planes in the angles. If a little more ammonia is introduced, several varieties of rhombic octahedra appear; if a little nitric acid is put in, the rectangular prism appears again. The change occurs, not by addition of new crystals, but by alteration of the original ones (St G. Mivart, 128, 129). The same mineral substance in a state of solution, when subjected to different conditions, gives out quite different crystalline forms; and, under further alteration of condition, will change form again (Bastian, II. 492). Temperature has much to do in varying the forms. Through this influence alone rounded and cellular forms are produced in lieu of angular ones. Temperature also affects the colorization (Ibid. II. 58-60). Light also alters the structural form (Herbert Spencer, I. 485).

The fact that the symmetrical forms of minerals are due to their components as acted on by surrounding agencies, affords the probability that such is the case in the production of vegetal and animal formations (St George Mivart, 188). The formation of crystals is wholly independent of anything like organic functions, of which they have none; and there may be similar formative laws for organisms (Ibid. 209). Fungi will alter their forms from the same germ according to the soil on which it falls (Ibid. 129). The common edible mushroom is cultivated with as much certainty as any other vegetable, although no seeds are ever sown. None but the required sort appears under the treatment pursued; whereas if the growth came from germs in the air, there would be many varieties (Bastian, II. 433). The rosebush, the hoof of a dead horse, and the dung of cats, have their appropriate fungi, which can scarcely arise from germs in the air, each electing its proper foundation (Mivart, 129). Extraneous growths of an abnormal nature, occurring on animal substances, demonstrate the formative properties of animal matter. The pattern on the diseased pelvis of a lion, of a very complex character, had not one spot or line on one side which was not represented, as exactly as it would be in a mirror, on the other. The eruptions of eczema, lepra, and psoriasis; the deformities of chronic rheumatism; the paralysis from lead; the eruptions excited by iodide of potassium or copaiba; the syphilitic caries of the skull; rheumatic and syphilitic deposits on the tibiæ, and other

bones; the effects of chronic rheumatic arthritis in the bones, ligaments, or cartilages; the fatty and earthy deposits in the coats of arteries,—all occur in exact symmetry (Ibid. 205).

There is vegetal and animal chemistry equally as there is mineral chemistry. Sexual propagation is in fact only a form of chemical union. The spermatozoa is the male product, and the ova the female. They coalesce, and the effect is a reproduction of the species to which the parent germs belong. But there is also asexual reproduction both of plants and of animals, the latter being such as are of low type; and this is an operation analogous to the mineral processes. Plants may be propagated by cuttings, or from bulbs thrown off, as well as from seed. In the Drosera Intermedia young plants are occasionally developed from the surfaces of the leaves while still connected with the parent plant. The Volvox and Hydrodictyon develop broods of young plants within themselves, and give them exit by bursting. The Polype, which is something intermediate between the vegetable and the animal, buds out from its parent stem, having a common alimentary canal through which the nutrition of all members of the united family is carried on, the whole presenting a tree-like aggregation. Some of the buds, instead of developing like the rest, are converted into capsules, in which eggs are formed. The repetition by cuttings, as with plants, may also be effected with these low animal forms. A Begonia leaf may be broken up into a hundred parts, and each part, in suitable soil, will become a perfect plant. In like manner a polype may be cut into several pieces, and each piece will grow into an entire form. The process may be repeated, so that as many as fifty polypes have thus resulted from a single one. Bodies when cut off regenerated heads; heads regenerated bodies; and when a polype had been divided into as many pieces as was practicable, nearly every piece survived and became a complete animal. Some of the lower Annelids, as the Nais, may be cut into thirty or forty pieces, and each piece will become a perfect animal. The recuperative power is displayed in the ability which some animals have to restore lost parts. Among the Hydrozoa any portion of the body can reproduce the rest, even when the greater half has to be reproduced. In the more highly organized Actinozoa the half of an individual will grow

into a complete individual. As the scale ascends this power diminishes. A lobster or crab can reproduce a lost claw. Some of the inferior vertebrata, as lizards, can develop new limbs and new tails, when these are cut off, and this several times over (Herbert Spencer, I. 175, 180, 203, 208, 216). A salamander also can renew its limbs (Darwin, *Descent of Man*, II. 385). In the superior forms the power is limited to repairing injuries, as in the junction of broken bones and the cicatrizing of wounds.

"A very curious instance of the modification of force producing a radical change in constitution is presented by bees when they have lost a queen. The workers are sexless, or rather, they are females with the reproductive organs undeveloped. When a colony is without a queen, one of the worker grubs is taken and fed on stimulating food, reserved for exclusive use by the queen. This strong diet soon develops the sexual organ of the bee, alters the shape of her tongue, jaws, and sting, deprives her of the power of producing wax, and obliterates the hollows in the thighs adapted for the transport of pollen" (Baring-Gould, *Origin and Development of Religious Belief*, I. 19, 20).

The processes we have had under consideration are all effected by analogous laws. The surface of the earth, through various operating causes, becomes comminuted into finer particles, and rendered mobile and susceptible by deposition in water. It then is capable of entering into more and more refined combinations with surrounding elements, chiefly atmospheric. At length life is evolved, first in plant forms and afterwards in animals. The vegetal forms have the power of assimilating to themselves the inorganic components, while the animal forms depend for their supplies on vegetable tissues, which they convert into flesh and other animal constituents. A formative power is apparent in the ingredients as acted upon by external influences. Parts enter into combination with suitable parts, and light, heat, and magnetism govern the results, arranging and diversifying the structures. As it is with minerals in their process of crystallization, so is it in the composition and renovation of organized bodies. The requisite materials are sought out and obtained through mutual affinities, and are put together in appointed forms.

The growth of all organisms from the primitive cell to the adult proportions, their continuous sustentation, with the constant reparation of wastes, is evidence of material gathered out of surrounding elements, and applied, in formative action, for the development of the individual object, whether appertaining to the vegetable or the animal world. Based upon such operations is the process, patent to every observer, of life evolved from decomposed organisms. Whether it be vegetation or animals that undergo decay, from their remains myriads of minute living forms of fungi and animalculæ are inevitably engendered. The question is, are these life forms absolutely the issue of the surrounding elements, or do they owe their origin to germs attaching themselves to the decomposing substances, and there fructifying ?

This question has long been the subject of controversy. The supporters of the germ solution allege it as a means of meeting a difficulty. The germs are not discoverable themselves, but it is thought that they must be there, because it is easier, in view of current processes, to believe in generation through this means than without it. But the difficulty is only postponed and not removed, for it has still to be considered how the first organism could have been formed without an antecedent germ. "With respect to spontaneous generation, while admitting that there is no experimental evidence in its favour, Professor Haeckel denies the possibility of disproving it, and points out that the assumption that it has occurred is a necessary part of the doctrine of Evolution" (Huxley, *Critiques and Addresses*, 304); a statement which Professor Huxley gives without disputing it, though himself an advocate for generation only by means of germs. The term "spontaneous generation," I may observe, as pointed out by Dr Bastian, is incorrect, there being no question of spontaniety in the process of the elimination of forms from pre-existing materials. Dr Bastian, in his able work, *The Beginnings of Life*, to which I have already had occasion to refer, details a number of experiments carefully conducted with the view of throwing light on this subject, of which I now avail myself.

The germ theory supposes that germs are floating in the air, ever ready to be made use of by the decomposing matter. The process of generation of life from this matter is carried on

so universally, and on such a scale, that it requires that the germs should be in proportionate multitudes, and everywhere present. But the fact is that few have ever been found in that position. For example, a vessel containing organic infusion has been placed by the side of a plate of glass smeared with glycerine to arrest what might be in the air, and the result has been that while the infusion in a few days swarmed with infusoria, the film of glycerine disclosed merely a very minute quantity of organic and inorganic *débris*, mixed with dead particles (II. 284). The elements of further compositions were thus found floating in the atmosphere, but not the germs.

Fungi have appeared in the interior of structures, some of which they could not possibly have invaded by intrusion of their germs from without, and these, consequently, must have been generated by composition of materials existing within. Bacteria and fungi have been found in profusion in the tissues and vessels of plants, into which the germs could not have passed from want of penetrating power (II. 318-322). Bacteria and Torula-like corpuscles occur in the cells of living plants, and in the central parts of plums and peaches, the external surfaces of which are perfect (II. 341). On shutting up silkworms in close damp bottles or boxes their blood has been found to acidulate, after which fungoid growths are generated within them, spreading themselves through the animals in all directions so as to cause death, and forcing themselves outside to their surfaces (II. 325-328). In this instance the results are apparently due to the treatment to which the insects were subjected, and the consequent decomposition of their blood, and not to introduction of germs foreign to them. Fungi in like manner are produced in the autumn in the blood of flies, and prove fatal to them (II. 330), an effect seemingly of climatic influence. Moving particles, some spherical and some line-like as Bacteria, were seen in the inner folds of the brain of a man who had died thirty-two hours before of rheumatic fever. No such organisms having been found in living patients, the conclusion is that they were formed in the brain *de novo* after death (II. 333-335). Bacteria have also been observed in the central parts of the organs of dead animals, as in a mass of brain tissue, and in the centre of the liver (II.

specks, and the staff-like bodies called Bacteria, first show themselves. Other forms, which are spherical or oval, and attached together as necklaces, will appear. Also the long jointed bodies called Vibriones. Later, Leptothrix filaments and Fungus spores will be produced (I. 267-277). After a time the Bacteria accumulate at the surface of the solution, and become motionless, being surrounded by a thin pellucid and almost jelly-like stratum. This pellicle gradually increases in thickness. Sometimes it breaks up and sinks to the bottom, and a more durable one may be formed. Or there may be no pellicle, but only flocculi, which after a time sink to the bottom. Torulæ cells will then appear. These multiply and remain motionless in groups (I. 278-283). Afterwards they develop into filaments (I. 292). Some of these produce bud-like spores. Then Protambæ and active Monads, which are animals, make their appearance (I. 441-444).

All bodies are made up of molecules. Simple substances are aggregates of similar atoms. Still more complex bodies will be formed of complex molecules. The process that occurs in the growth and variation of crystalline bodies is the same with colloidal bodies (II. 51, 52). Every germ, vegetal or animal, gradually ceases to be uniform. Minute structures arise which increase till different organs slowly appear (II. 124, 125).

The success of the experiment varies with the strength and character of the solution. Cheese added to an infusion of turnips produced marked results (I. 430 note). On varying the solutions the results varied, some of the experiments being sterile (I. 445, 446). In some solutions Bacteria prevail, and in some Torulæ. Acid and saline solutions favour Torulæ, putrescible ones Bacteria, and when impaired by heat nothing may be engendered but Torulæ. Bacteria and Torulæ appear in the same solution. Change the fluid and the forms change, as in the instance of crystals. Both may grow into Fungi (II. 143-146.) Iron introduced will develop green protoplasm, and unfold into Algæ (II. 158, 159).

There is no radical difference between Fungi and Algæ. The evolution of one or the other depends on the constituents

present (II. 158). The relationship between Fungi and Lichens is even closer. That between Algæ and Lichens is just as close (II. 159). Heat and drought are favourable to Lichens, and damp to Algæ and Mossés, which are inter-changeable forms (II. 164). From a single Lichen, under varying conditions of growth, will be produced twenty-three forms of what hitherto have been regarded as fresh-water Algæ. And these Algoid forms may have other totally different modes of origin. The Alga called Nostoc is produced from the Lichen called Collema. This occurs in different modes, and the Nostoc can change back into the Collema. Nostocs also come from other Lichens. No vegetable products are more liable to variation than Lichens. And there is the probability, from the circumstances of their growth, that mosses are produced from these complex sources (Appendix lvii.-lix.).

Most singular transformations are undergone by the Infusoria, vegetable forms changing into animal, and animal into vegetable. Bacteria, Vibriones, Leptotherices, Torulæ, Protambæ, Flagellated Monads, having animal constitutions, and Algoid filaments, are proved to be interchangeable forms (II. 162). An Amæba and a Fungus may interchange forms. Variation of the heat to which the infusions are subjected effects the alterations, a low degree favouring the production of the Monad, Amæba, and animalized forms (II. 231, 234). Fungi, Algæ, Lichens, and Mosses, constantly give birth to animal forms, such as Amæbæ, Monads, and Ciliated Infusoria (II. 434). The beautiful green Astasiæ and Euglenæ which occur in stagnant waters may produce the most varied animal and vegetal forms. Euglenæ have developed into Fungus-germs, Flagellated Monads or Zoospores, Diatoms, Algoid Corpuscles, Bacteria, Desmids, Pediastreæ, Algal filament, and Moss-germs (II. 434-453). Also into more decided animal forms, such as Amæbæ, Actinophrys, Ciliated Infusoria, Rotifers, Tardigrades, and Hematoids (II. 457-466). Algæ will give forth Ciliated Infusoria, and Vorticellæ. From the cells of Chara will come Monads, Amæbæ, Keronæ, Vorticellæ, Actinophrys, and Rotifers, which become the prey of other Infusoria (II. 467-479). A Vorticella and an Oxytricha may result from two contiguous Euglenæ or other Algoid vescicles.

Kerona Pustulata have given rise to Plæsconia Charon (II. 495, 497). Actinophrys and Ciliated Infusoria may come from vegetal matter. The vescicles of Volvox Globator have been transformed into Rotifers. Rotifers are also evolved from Akroid matrices (II. 506-510). Euglenæ are converted into Rotifers, Tardigrades, or Nematoids (II. 525). Water mites, or Acari, and ciliated embryos of Naïdes, are produced from the Nitella (II. 540). Mosses will generate free moving Amæbæ and living Zoospores, each with two cilia (App. (lxxii.). From Liverworts will come Spermatozoids, such as Spirillum and Vibrio, from which there may appear Monas Corpusculum; and this is again transformed into Amæbæ, and from the latter will be evolved the vegetal Algæ. These forms invariably maintain the succession described (App. lxxiii.-lxxv.). The lower Fungi are for half their life-history in an Amæboid condition, being then regarded as animals rather than Fungi. Zoospores are also produced from Fungi. Active Flagelliferous Zoospores come from potato mould, and there is such an intimate connection between animal and vegetable life that there are organisms of which it cannot be judged to which kingdom they belong. One and the same being may at one time exhibit the vital phenomena of an animal, and at another those of a plant (App. lxxix-lxxxi.).

A practical student of nature has been good enough to make me the following interesting communication. "Nothing," he says, "in all my studies is so wonderful to me as to watch the rapid powers of locomotion possessed by the vegetable animalcules under the splendid microscope I have. The Volvox looks like a round moon studded with emeralds, and is in perpetual motion, rotating, and darting about as if in search of prey. The motion is caused by its cilia, most minute hairs, which I can clearly see only with my $\frac{1}{12}$ glass, giving about eighteen millions of magnifying power. These cilia are like a corn field in the wind, and propel the Volvox through the water. The green spots on its surface are its spores, which it casts, and each becomes a living Volvox. Then the Vorticella (also a vegetable), is like a beautiful flower covered with waving cilia attached to a long stalk. This stalk contracts itself into a spiral form which it suddenly darts out to its full length, while the flower contracts as if in

the act of catching a monad, and the stalk as instantly collapses into its spiral form. I have seen these objects swimming about after prey, and it is difficult to imagine that they have not animal consciousness of what they are doing. So also with nearly all the organisms, which we are quite certain are vegetable. Thus life is but one in its essence, but where the animal begins and the vegetable ends, we can hardly tell at this moment."

The filaments of Oscillatoria Tenuis develop into perfect Euglenæ, from which come animalcules of two kinds. Then come Leptothrix filaments, after which young Oscillatoria again appear (Bastian, II. App. lxxxiii., lxxxiv.). Euglenæ and Astasiæ are capable of giving rise both to animals and plants, under the influence of varying conditions. One half of the same specimen may go one way, and one half the other. Euglenæ may produce Confervæ and Mosses, or else animals such as Rotifers, Nematoids, and Tardigrades. And as side products they will give Desmidæ, Diatomaceæ, Zygnemiæ, and nearly all the vescicular Infusoria. The larger Euglenæ are the common matrix of all the known forms of Infusoria, and the absence of light promotes the production of animals rather than plants. The smaller Euglenæ have not equal capacity for evolving animal products. The Volvox Globator as well as Euglenæ give rise to Amæbæ (App. lxxxv.-lxxxvii., xc.). An Astasia will become an Amæba and an Amæba an Astasia (App. lxxxix.). The greater number of the Infusoria reduce themselves, when the conditions are not favourable to another mode of development, into Amæbæ, and if an infusorial animalcule happens to reproduce itself by germs, it is always in the state of a Monad, which is the primitive form of the Amæbæ (App. xc.). Pseudo-Navicellæ are derived from Gregarinæ, and then become Amæbæ, and the Amæbæ become Gregarinæ (App. xci.). The Amæba often assumes the radiated form of the Actinophrys (App. xciii.) The Actinophrys Sol is developed into a Vorticella, and Vorticella into Acenita. Again the Vorticella is converted into an Actinophrys or a Podophrya, and ends by becoming again a Vorticella (App. xcv., xcvi.).

The animal organisms undergo strange transformations among themselves. When two or more Amæbæ come into contact, they may fuse together so as to form a larger individual

of the same kind, which creeps about and seizes food as its components had previously done. Fusions also occur between other units, producing dissimilar forms. The pellicle is a vehicle for such changes (II. 193, 194). The Amæba may become a Monad, or a Monad an Amæba (II. 231). Monads, Actinophrys, Peranemata, Amæbæ, and Fungus-germs, frequently proceed from contiguous portions of the same matter, and are interchangeable with one another (II. 492). Among Ciliated Infusoria, Vorticella have been metamorphosed into Oxytricha, and Oxytricha into Trichoda (II. 493). These Infusoria, after a life of great activity, during which by fission and gemmation they give birth to creatures similar to themselves, encyst themselves, and so pass out from themselves other forms. In this manner Monads, Amæbæ, and Rotifers may be produced (II. 500, 501). A Rotifer will develop into a very vigorous and most voracious Actinophrys, which acquires considerable dimensions. And an Actinophrys may become a Rotifer, a Nematoid, or a Tardigrade. An Actinophrys, again, will become spheroidal, and change into a Ciliated Planariole. This increases in size, and leads a very active life for about ten days, when it is encysted, and then through an embryo form becomes one of the Tardigrades (II. 523, 524). Amæbæ, Monads, Ciliated Infusoria, Rotifers, and Nematoids, are convertible into one another (II. 558). A Rotifer may be produced direct from a large Euglena, or a large mass of protoplasm and chlorophyll separating from the wall of a Nitella-filament; but should the Nitella mass or Euglena be small, there will be a succession of transformations to an Actinophrys, an Amæba, and a Ciliated Infusorium, before the Rotifer emerges. The Medusæ and Distomata also come forth direct when the eggs are large, and when small they appear through intermediate forms (II. 570, 571). "It is much to be desired," observes Dr Carpenter, "that observers should devote themselves to the study of even the commonest and best known forms of animalcules, since there is not *a single one* whose entire life history from one generative act to another is known to us" (*On the Microscope*, 482).

The processes now described forbid the idea of germ generation. When the same organic substances are found producing dissimilar forms, and these interchanging with one

another backwards and forwards; one sort of vegetation convertible into another sort; vegetal changing into animal life, and animal life into vegetal; one form of animal altering into another form, and reverting afterwards to its first form, with sometimes a chain of transformations of animal forms in established recurring succession,—it is apparent that alterations wrought on the components by influences affecting them, give rise to the forms and their changes, and not an ever varying supply of germs, for which, moreover, the sealed flasks give no means of access.

The rule that sexual intercourse is ordinarily necessary to reproduction lies at the root of the assertion of the opposite germ theory. But this rule we know is not an absolute one. Propagation by fission and gemmation, where it takes place, affords evidence of perfect forms being introduced without the operation of the sexes. Dr Bastian's facts give to asexual operations a wider scope than hitherto has been observed and acknowledged, and show that the one system, by advanced developments, passes into the other. Even fertile germs, it appears, are induced asexually. Ciliated Infusoria are produced by fission, and more rarely by gemmation; but they also spring from embryos formed out of nucleated substances, and germs created in the tissues of the organisms (App. xcviii., c., ci., civ.). Nematoids, which are a species of worm, are at first sexless, and afterwards are constituted as males and females. Dr Bastian gives the drawing of a female Nematoid which had been produced from the plant Euglena with eggs within her (II. 525, 527). Rotifers and Tardigrades, animals which come from tufts of Moss and Lichen, multiply their species by eggs. These eggs, as also those of the Nematoid, are large, and are never discernible in the atmosphere (II. 535 and note, 536-538). Acari, as well as Nematoids, are produced without sexual contact, and afterwards display the sexual forms perfectly (II. 551). Amæbæ, Monads, and Ciliated Infusoria, equally as Rotifers and Nematoids, eventually multiply their kind sexually (II. 558). There are plants which give forth products sexually and asexually in alternation. Among animal forms the Aphides are so circumstanced. From the fertilized eggs of perfect females will come imperfect females, the births

from which will be viviparous, and after a time oviparous births will occur. Lepidopteræ, Psychidæ, and Tineidæ have produce without contact with males, none of which have ever been found (Herbert Spencer, I. 211, 214, 215). There are hermaphrodite plants and animals. These, as a rule, do not fertilize themselves, but pair with others (*Ibid.* I. 278). When the sexes have been established, and propagation is carried on through this means, the laws of heredity come into operation, a conservative principle is introduced, and the forms become less subject to variation (Bastian, II. 101, 607, 637).

The operations of nature, and above all the great question how animated forms were first produced, attracted much attention in early days. The cosmogonies and mythologies then current were projected in the endeavour to solve or elucidate the difficult problems which the existence of all things around offered to view. Anaxagoras of Clazomenæ (B.C. 530) considered that all matter was penetrated by "an immaterial spirit (νοῦς) whose action produced order and harmony in chaos." "This spirit he did not regard as divine." It was "the principle of life, diffused throughout the world, energizing nature, intelligent, individual, wise. By it the world was not created, but was moulded out of pre-existing material" (Baring-Gould, *Origin and Development of Religious Belief*, 298, 299). Plato (B.C. 390), exalting God as incorporeal and incomprehensible, attributed creation to a Demiurg, who "made the universe out of pre-existing material, according to the ideas of good projected upon matter" (*Ibid.* 302, 303). The legend of Cronus emasculating his sire Uranus, with which the birth of Aphrodite, the goddess of propagation is connected, has been viewed by Macrobius, (a writer of the fifth century,) as indicating "that, after the finite world was completed in all its parts, the productive or creative influences which had descended from the heavens on the earth and had called forth new creatures into being, were cut off, or entirely ceased; and that the maintenance of animal and vegetable nature was thenceforth supported by another method, viz., by that of propagation" (Prichard, *Egyp. Myth.*, 26, 27). These ancient speculations fall in very remarkably with the theory

I am led by the results of modern investigations to advance, namely, that all forms have been composed originally out of the surrounding elements, and when established persistently are constituted to continue themselves by sexual generation.

The early inquirers looked on life as a consequence of organization. Their thought was that the frame was first fashioned out in all its parts, and life then imparted to it. But the processes we witness in the production of Infusoria, show the reverse to be the method (Bastian, I. 59, 169, 170). Life takes effect upon a formless substance, which is termed Protoplasm; but how what is lifeless becomes imbued with life, we are unable to discern (*Ibid.* 128, 153). Philosophers do not pretend to explain the mode of connection of spirit and matter. They only allege their inseparability (Büchner, *Force and Matter*, Pref. to third ed. xxvi). "Life in its inmost relations is certainly a book with seven seals—riddle upon riddle." We only skim its surface. It originates from a conjoint action of chemical and physical forces (*Ibid.* Pref. to fourth ed. lii). The non-living particle, observes Professor Huxley, is inert, the living particle exhibits endless action. "What," he asks, "is the cause of this wonderful difference between the dead particle and the living particle of matter appearing in other respects identical? that difference to which we give the name of Life? I, for one, cannot tell you. It may be that, by and by, philosophers will discover some higher laws of which the facts of life are particular cases—very possibly they will find out some bond between physico-chemical phenomena on the one hand, and vital phenomena on the other. At present, however, we assuredly know of none" (*Lay Sermons*, 76). Then he describes the earliest living substance that is discernible. In a drop of blood, by means of a microscope, will be seen innumerable little coloured corpuscles, which give the colour to the blood, and a smaller number of colourless corpuscles, which are rather larger in size and of irregular shape. These, if kept to the temperature of the body, exhibit a marvellous activity, "changing their forms with great rapidity, drawing in and thrusting out prolongations of their substance, and creeping about as if they were independent organisms." This substance is the protoplasm. It is found in the skin, the lining

of the mouth, and throughout the whole frame-work of the body. The earliest development of the embryo is an aggregation of such corpuscles, and "every organ of the body was, once, no more than such an aggregation." Thus a nucleated mass of protoplasm is the structural unit, by a repetition of which, variously modified, the human and all other animated bodies are built up. "Beast and fowl, reptile and fish, mollusc, worm, and polype, are all composed of structural units of the same character, namely, masses of protoplasm with a nucleus." "What has been said of the animal world is no less true of plants. . . . Protoplasm, simple or nucleated, is the formal basis of all life. It is the clay of the potter. . . . Thus it becomes clear that all living powers are cognate, and all living forms are fundamentally of one character. . . . Carbon, hydrogen, oxygen, and nitrogen, . . . when they are brought together, under certain conditions, give rise to the still more complex body, protoplasm, and this protoplasm exhibits the phenomena of life" (*Ibid.* 126-129, 135). Life introduced by means of this plastic protoplasm works out in the system its destined form, and fresh supplies of matter are continually taken in and vitalized, and assimilated to nourish the organism and repair waste. But how the first adhesion of life occurs, or how the process of nutrition is effected, are beyond the limits of our observation (Bastian, I. 55 ; II. 26). All chemical changes are equally inexplicable. It is unknown why oxygen unites with hydrogen to form water, and hydrogen with nitrogen to form ammonia (*Ibid.* II. 26, 27).

"The proximity of physical masses does not explain gravitation; the existence of animal or vegetable principles in an organic form in no measure explains the phenomenon of life. The flow of nervous fluid from the brain does not explain thought; the act of volition does not explain muscular movement, neither does the flow of nervous electricity explain it" (R. S. Wyld, *The World as Dynamical and Immaterial,* 16). "When we look about us towards external objects, and consider the operation of causes, we are never able, in a single instance, to discover any power or necessary connection, any quality which binds the effect to the cause, and renders the one an infallible consequence of the other. We only find

that the one does actually in fact follow the other" (Hume, *Essay on the Human Understanding*, 44).

The experiments made with infusions in flasks represent, in miniature operations, the same in kind carried on with vast results in ponds, lakes, rivers, and ocean beds, and in all places exposed to humidity (Bastian, I. 431; II. 162). Still, only the very lowest forms of vegetation and animals are embraced in these operations. The question is, have the higher forms been similarly produced?

Our familiar experience of life evolved from germs and embryonic forms, generated by the means of sexual intercourse, gives us the rule of reproduction governing the existing species; but it will not account for the first introduction of these species, which necessarily was effected without antecedent parentage. The higher Infusoria also, we have seen, are finally brought under the law of heredity; and yet we know that there was a time when they were composed and endowed with life without the intervention of parents. In their instance, the germ is not a primitive necessity, but the result of a secondary condition. Fact and theory are here not in discord; but we must be careful to discriminate the nature of the fact. There could be no operative germ without a preceding germ producer; and in the Infusoria we see how the germ product is brought about without sexually constituted parentage. Nor is any other rule for the primitive production of the embryonically constituted germ conceivable. We are warranted, then, in concluding that the superior races may have in like manner been brought into being. The causes that have served to introduce the Infusoria, we are warranted in supposing, may be those likewise to which the higher orders owe their primitive existence, their law of sexual reproduction becoming established among them when, as with these Infusoria, they had attained their ultimate perfected forms. "Spontaneous generation played, no doubt, a more important part in the primeval epoch than at present; nor can it be denied that in this way beings of a higher organization were produced than now" (Büchner, *Force and Matter*, 84). The elements of all are the same, gathered similarly out of earth, water, and air; and, on decomposition, the constituents of even the highest forms afford materials for the organization of the lowest of the Infusoria. There is nothing,

then, in point of constitution, that essentially divides or distinguishes these classes. All are put together with the universal protoplasm, compounded from similar materials. The phenomena of life, together with the processes of development, nutrition, and decay, are the same in all. If the passage from asexual to sexual production is bridged over in the instance of the Infusoria, may it not equally have been bridged over in that of the higher forms? The powers in operation are illimitable; and a proportionate magnifying of the powers might produce results of any degree of consequence. Those conditions which bring into being the minutest filament, or the microscopic jelly speck, would, if adequately increased in scope and potency, generate a fungus of any dimensions, or a jelly fish. We, in fact, witness the growth of considerable fungi (mushrooms) without germ origin. What causes diminutive articulations, operating on a larger scale might lead to structures of any ascending size. To draw any line, as an impassable one, in these operations, is not possible. The beginnings of form have continually been given forth. Geologic remains exhibit a constant succession of changes wrought in animated nature. Species after species have been gradually withdrawn, and fresh species introduced. The operations sometimes have been on a scale to represent new eras of creation. The carboniferous and cretaceous systems are of this order, as also are the gigantic saurians of the Oolitic period, and the huge mammals of the Tertiary.

The system prevailing in the production of the Infusoria affords us another important guide in apprehending what the general processes of creation may have been. There are doubtless numerous transformations occurring among them, but the rule is a multitude of independent forms simultaneously generated, and of very various shapes. As broad and as scattered as the stagnant waters may be in which these operations are carried on, so surely will every corner thereof, in all places, teem at once with life. The ocean beds, we find, swarm in breadths of hundreds of miles with animated beings engendered all together. Fungi, lichen, and mosses, with magic celerity, cover all surfaces appropriate to them. Grass and herbage of all sorts spring into being simultaneously in all suitable regions; and the vast forest growths occur all

together. Are we to think that the rule operating in the instance of all the Infusoria, and of all vegetation, small and great, is not the rule that occurred when the higher forms of animal life were introduced to stock the globe? "Is it reasonable to suppose the Almighty would have created one seed of grass, one acorn, one pair of locusts, of bees, of wild pigeons, of herrings, of buffaloes, as the only starting-point of these almost ubiquitous species?" (*Types of Mankind*, 73, 74). Professor Agassiz, in respect of the beasts of prey which have to depend on animal food, asks the pertinent question, "Was the first pair of lions to abstain from food until the gazelles and other antelopes had multiplied sufficiently to preserve their races from the persecution (to extermination) of these ferocious beasts?" (Ibid. 74). This is a very extensive daily need, not only on the part of the carnivorous mammals, but of the multitudinous birds, fishes, and reptiles that have to seek their supplies by feeding on other creatures. The whale alone takes in myriads of molluscs at a mouthful. The fair conclusion is, that what we see to occur in respect of the Infusoria, and the plants in general, is the method that has been taken in respect of the rest of the animated creation.

The constituting elements have everywhere abounded, ready to be brought into combination whenever acted upon by the equally present powers of nature. Have those which operate with such prolific effect in bringing the lower forms into existence, been placed under the closest limitations when the higher forms had to be evolved? The various centres occupied by peculiar products, many of which could not exist but in such centres, involve independent creations. The marsupials of Australia, and the sloths and armadillos of South America, must have been raised up each in their proper regions. In parallel latitudes in Australia, South Africa, and Western South America, the faunas and floras are of a character than which nothing could be more utterly dissimilar (Darwin, *Origin of Species*, 377). Natural barriers of any kind, or whatever impedes free migration, serve to create spheres of distinctive creations. For example, the products of the New World stand thus distinguished from those of the Old. In the seas on each side of America there is hardly a fish, shell, or crab in common, though separated only by the narrow

isthmus of Panama. There is not a single mammal common to Europe and Australia or South America. There is a great difference in the marine faunas on the opposite sides of almost every continent (Ibid. 377, 378, 382, 388). There is evidence of separate creations, where, on the other hand, similar products are found in distant, unapproachable localities. On mountain summits, such as those of the Alps, the Pyrenees, and the White Mountains of the United States of America, there is an identity of plants and animals, with wide intervening lowlands, where none such could exist. On the lofty mountains of equatorial America, on the highest mountains of Brazil, on those of Abyssinia, on the Himalaya, on the uplands of Ceylon, the volcanic cones of Java, the mountains of South Australia, and of New Zealand, are plants common to Europe (Ibid. 395, 405). The trout north of the Alps are identical with those south of the Alps, with insurmountable ridges between them. In like manner, the chamois of the Pyrenees are the same as those of the Alps, with plains dividing them impassable to such animals (Vogt, *Lectures on Man,* 216). The whalebone whales of the Arctic and the Antarctic seas are alike, having the waters of the torrid zone lying between them, which, observes Lieut. Maury, are "as a sea of fire, through which they could not pass" (Murray, *Geographical Distribution of Mammals,* 209). Wherever new countries have been discovered, through the remotest antiquity, in every region, except in small islands, strange races of men have been met with already in occupation, besides the stocks of inferior animals and plants (Vogt, 423 ; *Types of Mankind,* lxviii.). When America was discovered, between three and four centuries ago, the whole region, from the Arctic zone to Cape Horn, and from ocean to ocean, was found inhabited by populations dissimilar as to physical traits from any races of the Old World, speaking languages bearing no resemblance in structure to other known languages, and with animals and plants specifically distinct from those of Europe, Asia, Africa, and Oceana (*Types of Mankind,* 274). Mr Darwin, while accounting for all varieties of the animal creation as descended by transmutation from some one primitive, humble, organism, in contemplating the occupation of all parts of the earth, however divided by mountains or oceans, with their respective

fauna and flora, makes the concession, "We are often wholly unable to conjecture how this could have been effected" (*Origin of Species*, 495). Mr St George Mivart points to what is, in fact, the only escape from the dilemma. All geographical difficulties, he observes, would disappear, if we could concede the independent formation, in different regions, of all the organic frames, however high in the scale of nature, equally as may be conceded as to the Infusoria (*Gen. of Species*, 172).

The lesson appears thus consistent and complete on every side. The way in which the Infusoria are daily brought into being in all parts of the world, is evidence of a method of primitive generation, the limits of which it is arbitrary to confine to them alone; and the existence everywhere, in all regions, and at all times, of higher organizations, including man, in localities between which no means of transmission can be conceived, some with special constitutions disabling them from living elsewhere than where they appear, admits of no other explanation than that they were generated where found; whereby we seem driven to conclude that what the laboratory of nature works out, from surrounding materials, before our eyes, on a small scale, has been worked out, in past times, on a much larger one, to the creation on one footing as to method, as it indisputably has been as to material, of all the animal structures the world has possessed, the most important as well as the lowest.

When we cast our eyes abroad upon the universe, we appear to have before us, in the grandest proportions, just such an exhibition of the powers of nature operating for the development of ulterior forms, as we see exercised, in the minutest, in the production of the infusoria. The construction of the heavenly orbs from nebulous matter is a theory that receives support from the revelations of the spectroscope. "Some among the nebulæ manifest, under the spectroscope, the same lines as the fixed stars; others, however, are recognizable, by the lines of their spectra, as glowing gaseous masses. The importance of this discovery for our cosmogonic theory is self-evident. It actually proves the truth of our previous assumption that boundless space contains not only completed worlds, but such as are only in process of formation, or only just developing out of a gaseous state" (Strauss, *The*

Old Faith and the New, 188). That is, the indeterminate gases, floating in the measureless ether, are being collected and solidified into specific forms, having specific uses and functions, just as organized objects are constructed on earth mainly from the gases in our circumambient ether. The nebula in Canes Venatici (Guillemin, Fig. 156) affords an illustration of the apparent process. A rotating mass of nebulous matter is observable whirling round in a spiral form, having a globe seemingly forming in its centre or nucleus, and another being consolidated and cast off at its outer extremity. Similar exhibitions are given in the nebulæ in Virgo, Leo, and Pegasus (Fig. 157, 158), and the number of such observed phenomena is an increasing one. "We have noted forty spiral nebulæ, and thirty more in which this form is suspected (Guillemin, 403). Small brilliant stars are mixed in with these nebulæ, which probably do not belong to their systems, but lie beyond them, and are visible through them. Viewing the whole immeasurable expanse of the universe as sown with these globes, some under process of construction out of the prior formless nebulous matter, and some fully developed and holding their appointed courses, what have we but an exhibition, on a stupendous scale, of what is observable in a drop of stagnant water, where unformed matter is being composed into minute jelly specks, and other more advanced organized shapes?

The theory of Mr Darwin, which has met with so much attention, does not consist with the facts on which I have been building. He supposes that the various forms of life have been derived from one another, through graduated changes, so that the whole may at length be traced back to some one very humble primitive organization. But in the generation of the Infusoria we see, daily, multitudes of very diverse forms brought into being, not necessarily derivatively, but also simultaneously and independently; and the stocking of the whole globe, in all its parts, however unapproachably separated, with appropriate flora and fauna, also speaks of independent and not derivative creation.

Mr Darwin's theory labours also under other serious objections of a character that should be fatal to it. He has to beg his way at every stage, and, the necessary facts being wanting, to

raise his system ever upon supposititious foundations. He wishes us to disallow any real distinction between varieties and species (*Origin of Species*, 3d ed. 54, 59, 61), while the laws of hybridism ever place an effectual barrier between violent intermixtures, thus marking the distinctiveness of species. Either from want of adaptation, or from aversion, the species do not cross with one another, or, if they do, and have a progeny, it is infertile. Varieties, on the other hand, intermix freely, and have fertile and even improving offspring. But if species are only varieties, then Mr Darwin hopes to make it clear that because we may effect a hundred varieties of apples, or of pigeons, an apple may be transformed into a pear, or a pigeon into a crow, and so onwards from stage to stage of conversion. The intermediate shapes are wanting, and, conveniently, he supposes them to have been exterminated (194), and not even adequately preserved in fossilized condition (197). The close gradation of shapes has convinced him that the ape is the nearest link to man at the ultimate end of the chain, the ascidian being the first approximation to the vertebrates at the other end. But if all come from a primeval germ, and gradation of shape is to rule the conclusions, he must link on the vegetable kingdom to the animal, and even the mineral to the vegetable, the lines between these various orders being indefinable. His great instrument of change is what he terms natural selection, or the object seeking to better itself. In this way fins may become legs or wings, as instanced by the penguin helping itself along upon shore with its water propellers, and the flying fish darting out of water and sustaining itself in the air by the spread of its lateral fins (200, 201). We are entitled to figure to ourselves interminable generations of fishes struggling to clamber upon land, until at last some advanced specimens succeed, and, gradually controlling their gaspings, accustom themselves to prolong life on shore; after which, exercising, with intent at improvement, their ill adapted members, they end by developing these into well-jointed limbs; and whisking their scaly tails about, eventually fringe them with hair! But there are still stranger conversions to imagine, as of an oyster into a peacock, or of a midge into an elephant. Certainly how

so complicated an organ as the eye can have been produced, on such a principle as self-improvement, confessedly baffles conjecture; but still, to avoid shipwreck, Mr Darwin has to suppose such a result possible (205-209). Then, in some instances, the process of change involves retrogression, not progress. Mr Darwin's ascidian, for example, begins life as a free moving animal, and ends by becoming a plant-like object fixed to a rock like a polype. And through what propensities a stately oak, spreading its branches to the winds of heaven, should dwindle into the humble water-buried ascidian, it is impossible to conceive, though the change is unavoidable on the supposition of all forms being traceable to a primeval germ. Every parasitical object has necessarily come into being after the production of the form on which it feeds. Is it by transition that we find on man the *pediculus* which nourishes itself upon him? Mr Darwin and his admirers afford us no replies to these awkward questions.

Dr Strauss is one among the many in the ranks of the learned who have accepted Mr Darwin's theory. He thus endeavours to illustrate the development of form through the operation of the instincts and habits of the animal itself. "Let us suppose," he says, "a herd of cattle of primeval time to be still destitute of horns—only possessed of powerful necks and protruding foreheads. The herd is attacked by beasts of prey; it defends itself by running against them and butting with the head. This butting will be the more vigorous, the bull the fitter to resist the beasts of prey, the harder the forehead with which he butts. Should this hardening in any individual have developed to an incipient horny accretion, then such an individual would have the best chance of preserving its existence. If the less well-equipped bulls of such a herd were torn to pieces, then the individual thus equipped would propagate the species" (*The Old Faith and the New*, 217, 218). It will be observed how determined the process of begging resorted to in view to establish the required results. But are they established? We may have the thickening of the frontal bone, and the production on it of excrescences. But why are these latter, in their ultimate development, ever confined to a pair correspondently arranged, tapering to points as if constructed under an artist's eye? We might look not for

two, but twenty such developments, forming a regular *cheval de frise.* Why do we never even see the fabled unicorn? How is it that elephants, the most violent butters in the world, have their horns, (so to call them,) growing out of their mouths, and not from their foreheads? Can the beautiful convoluted ornaments on the head of the antelope, or the complicated branching antlers of the stag or reindeer, many pointed, with each point on the one horn matched by a similar one on the other, be possibly due to the art of butting? The butting would splinter off the branches, but assuredly not favour their symmetrical growth?

It is a great problem what may be the power by which the processes of creation are effected. We see them carried out by means of unerring laws, acting upon materials constituted with unvarying properties. As certainly as stated influences are brought into play, so surely do particular effects follow. Are the laws all sufficient for their purposes? Or is there some ultimate designing and governing power putting the whole into operation, and directing every result to its prearranged ends? In admitting matter, with its inherent properties, to be eternal, are we necessarily to conclude that its apparently self-existent atoms are endowed with independent action, subject only to the unalterable laws ever influencing them in their combined relations? Is it possible that without a propeller or governor they should have not only action, but concerted action? Finite although our knowledge, our thoughts are ever stretching to the contemplation of the infinite. And when we find the cause of life lying out of the reach of our perceptions; when every natural phenomenon is the result of some operation the root of which we are unable to discern; when every thing is ordered in the expression of design, and adaptibility of means to ends, with a perfection and success immeasurably beyond our faculties to devise or accomplish,—what legitimate conclusion can be drawn but that there is some unseen unerring power, existing beyond all we know of physical nature, effecting everything?

The scheme of creation directs us by analogy to a like conclusion. In every observable direction centralization is the rule maintained. The planetary system, in which we stand, has its governing orb, controuling, influencing, and vivifying

all the members of the community. This group is one of myriads of other such groups, constituted together; and all, it is thought, are circling round some common centre in appointed order. The earth has its proper sphere of function, generating all things pertaining to it, by resources drawn from its interior; its exposed superficies, and the surrounding atmosphere; and by a binding power belonging to it, it holds all in their places on its surface. Every organized object on the earth, vegetal or animal, has equally its governing centre. The rootlets of the plants draw up the needed nourishment; the leaves expand and imbibe their appropriate supplies. Every particle responds to its uses for the benefit of the aggregate whole. It is as if an inner chieftain governed and directed every operation for the advantage of the corporate body. In all the animated creation this directing centre of the system is made very apparent. The component atoms constituting their forms are infinite in their number and varied distribution, but there is a marshalling power in each organized structure, making every part work together for the good of the whole. The life and well-being of the individual are carefully guarded, its wants assiduously supplied, its desires satisfied, its wishes obeyed. Some of the operations are executed with consciousness, and some unconsciously. In the human body there may be said to be three centres of rule, the automatic, the animal, and the rational (Wilkinson, *The Human Body and its Connexion with Man*, 17). Many of our functions are carried on through the means of unconscious agency. "The bodily organs, as the liver or the kidneys, require to exercise processes of selection, and acts of composition and elimination, to which nothing less than a stupendous bodily judgment is adequate." Breathing, eating, and walking, are maintained by unconscious operations. The heart, as the supreme organ of the body, has a complete orbit of its own. The brains and nerves are the mental organ. The lungs, an intermediate field, lie between the mental and the bodily organs. But every part contains the rest. The brains, the nerves, the blood-vessels, the liver, are all everywhere. The body is telegraphic, with various stations. The messages are according to the organs; and there is one fountain-head. "When an impression appeals to it (the brain)

from the body through its quasi-sentient nerves, this mounts to the grey centre to which the nerve carrying the impression belongs ; an instant organic determination then occurs in the centre, a decision takes place, and a motion is sent down through the corresponding motor nerve to the parts which the latter supplies. For example a pinch applied to the leg lodges its complaint at the grey centre, which at once by its nerves sets the muscles and the limb in that motion which enables the part to escape the distress." "The spinal cord acts as if it were a sensible animal, guiding the fingers, for example, to the seats of pain by its automatic endowments" (Wilkinson, 5, 8, 9, 40, 255). The stomach, provided with a valve, subjects the food introduced into it to the chemical action of its gastric secretions, carefully retaining it until it is reduced to a state to be passed forward and assimilated by the system ; and if what is noxious to the body is introduced, with violent efforts it will eject it by the shortest passage ; that is, by the way by which it made its entry. If prejudicial influences should have invaded the body, by means of acute pain, spasms, convulsions, fever, perspiration, rashes, or diarrhœa, the virus will be discharged and the equilibrium restored. If any lesion occurs to the frame, then the proper vessels send forward the appropriate materials to restore the part as far as circumstances will permit. A broken bone is re-united with osseous deposits, lacerated flesh is repaired with fibrous matter, and a fresh cuticle is formed to cicatrize and close-up a wound. The governance exercised from the conscious centres more readily declares itself. From the animal centre flow the emotions and passions, and if these are to have healthy action, they must be directed and controuled by the thought and will proceeding from the rational centre, in which the ultimate dominion over the whole system is consciously exerted as by an enthroned and ever-watchful ruler. To him all the conditions of the corporate body are disclosed; by him all its powers are known and estimated, all its necessities felt, all its welfare judged of, and all its appointments and courses laid down and effected. In the sense of the supremacy and the directness of this his power, the minor individualities are absorbed in the being of the one identifiable and conscious unit.

If then there is a central governance for every member of the physical creation, for the orbs launched in space, and for the animated forms of which we are conscious on our globe, is it reasonable to suppose that the influences which pervade the universe are represented by so many independent laws, without an intelligence exerted over all to direct these laws to their appropriate ends? If there is no such ruling mind, then are we all the creatures of chance, left to the fortuitous combinations which the insentient elements and powers existent around us may bring about. Such a conclusion should be repelled by every rational mind. The unseen ruler may not himself be discernible, but his acts are everywhere demonstrated. If there is a feature characterizing this creation, it is eminently that every thing connected with it is stamped with proofs of forethought and design. The vast celestial bodies that occupy limitless space, are apparently grouped together in well ordered arrangements of distances and gravities mathematically adjusted. They influence each other, but each holds its measured and appointed course without collision with its neighbours. The movements of all are so precisely regulated as to give us measures of time of the utmost possible practical accuracy, and are so exceedingly rapid as to entail inevitable catastrophes and destructions, but for supreme direction. The adapted forms observable on the face of our globe are beyond computation, and nowhere is there an organized object not properly fitted for the ends of its existence. If every connected atom in each being has its appointed place, and performs its required functions with unerring certainty, much more does the entire organism, in its construction and complicated workings, manifest intelligently directed action; and the individualities, infinite in number, are all framed upon broad principles of universal law, exhibiting at the same time endless but always suitable diversities. To suppose that the whole is due to unintelligent agency, appears a mockery of the understanding.

The combination of the emotional element deepens the testimony which is presented by the perceptive and reflective powers exercised on what surrounds us, and this source affords even a truer sense, to those who profit by it, of the proper aims of our being, than can be attained by the mere contemplation of

the visible creation. The mind so working travels beyond the limits of the outwardly perceptible to fathom what belongs to the unseen. This is no mere effort of the imagination. The introduction is to a field of study, as solid in its realities as any to which the observation of the physical creation can lead. If the outer man is affected by all the conditions to which he is exposed, whether of climate, food, clothing, domicile, occupations, or habits, equally is the inner man susceptible to all moral influences with which he is associated. What he hears from others; what he learns from books; what comes to him from his own perception and reflection; the example of others; their direct monitions and exhortations; the lessons of his own self-control; the course of action to which he commits himself; the misrule of evil or the rule of good; the domination or the subjection of the passions; a heart shut up to a consideration of its own wants, or expanding to supply those of others; desires centring on things of sense, or in pursuit of spiritual renovation and instruction; an ambition simply to stand well with fellow-men, or the laying bare every thought and motive to the searching scrutiny of an unseen, ever watchful, and most sensitive, inward monitor;—all these agencies govern the development of the inward man as sensibly as the physical appliances influence the condition of the outward man. As the infant, at first helpless and altogether dependent on another, gradually acquires strength and stature until advanced to the full-grown proportions and powers of the matured man, so also progress the cultivation and development of man's sentient being—his other, better, and truer self. The whole is one consistent process of creation. Every material and tangible element entering into combination with the physical body, whether it be derived from the globe itself, or from the creatures dwelling on its surface, affects the physical condition, it may be for good, or it may be for evil, according as the eternal laws governing matter are obeyed or set at naught; and every inner moral application enters equally into the constitution of the moral and spiritual entity, and promotes, or retards, his advancement.

No one can exercise himself in this latter field without having the consciousness of a being beyond him—one above and

outside himself, and yet intimately and inseparably associated with him. If there is a mystery attaching to the constitution of the physical state in the access and the phenomena of life, that root of all power in animated nature, that ultimate and cherished possession to benefit and sustain which every effort of which the individual is capable is directed, so also is there an equally unfathomable root planted in the spiritual man, the cultivation of the relations with which becomes his highest, and in the end absorbing aim. Has he a request to make out of the field of his own possible exertions—he addresses it there; has he a want to meet for which all ordinary resources are insufficient—he there seeks for a supply; is he in danger, sickness, sorrow—thence he looks for deliverance; and who that so exercises his spirit, has found the resource a vain one? Above all, when evil rises within him, when the mind balances between what should be done and what avoided, this helper, when appealed to, is unfailingly present, and his directions and supports are never otherwise than those most suitable to the occasion consciously laid before him. What have we here but the Supreme Creator and Ruler of the whole system,—some power superior to, and independent of, all other powers, intelligently directing them? The contemplation then of the moral field, equally as that of the physical, leads to the conclusion, without which none of the observed phenomena can be adequately accounted for, that the processes of creation, in every branch, in this well ordered and responsive system, are under the appointment and control of a central universal power directing all things in the supremacy of his wisdom, to work together for ends to which he has appointed them.

We may be incompetent to judge fairly of what lies beyond the range of our possible observations. But it is a legitimate, and in fact an unavoidable question, which must present itself to every reflective mind, what is the end of man? Is he confined to the field presented to his physical vision, or do his moral perceptions and desires warrant his looking beyond this to another and superior sphere of existence? He sees that the essences of matter never perish. Is his essence, after conscious identity has been raised up within him, to be dissipated to a condition wherein this identity is to be realized no more? He has the sense of an eternity; is there no

portion therein for him? He knows of infinity of space; is he forever held to the narrow bounds around him? He aims at a standard of excellence higher than the infirmities attaching to his being in this life permit of his attaining; are these aspirations given to him in vain? He has placed before him goals of measureless goodness and felicity; may he never approach them? Is he gifted with apprehensions, faculties, and desires, the ultimate scope of which may never be arrived at? Is the existence of the Almighty Ruler of the Universe brought home to him, and his intercourse with him restricted to the fleeting imperfect opportunities of this life? Conscious of a two-fold nature, the one frail and perishing, the other ever expanding in limitless growth, are the two necessarily to end together? Is the whole discipline of life, instituted and maintained, as the individual advances to the term of his physical existence, with ever increasing attention, demonstration, and profit, to be disallowed at last by the obliteration of the being so carefully and assiduously cultivated?

I think if a man will but use the opportunities at his command for observation and reflection, he must come to the conclusion that the course of nature is due to some higher ordering than the mere operations of its governing laws, and that the ultimate sphere of our sentient beings is not restricted to the short, troubled, and comparatively objectless career we have on earth.

II.

THE ANTIQUITY OF THE EARTH AND ITS HUMAN INHABITANTS.

THE crust of the earth being composed of numerous strata, consisting of detritus of older formations and fossilized deposits of vegetal and animal remains, laid down gradually and successionally by means of aqueous agency, we have before us a testimony, which all may read and apprehend, to the exceeding age of the globe we occupy. The fact of this vast antiquity, when first disclosed to geological observers, ran counter to prevailing belief, and naturally met with much opposition; but it has established itself against all reasonable objection, and is accepted now, on all sides, as ascertained truth. We have evidence of the prevalence over the whole earth of the ancient Silurian ocean, covering everywhere the primitive granite which was destitute of life. From what earlier stage the earth passed into that condition we can judge only inferentially. The granite and the water being of composite character, must have been produced from the combination of primitive elements, slowly and persistently, as in all observable terrestrial operations. After this, also by slow gradual advances, the passage had to be effected from the inorganic and lifeless to the life-possessing stage. There were then maintained those repeated upheavals and accumulations which raised land above water and introduced terrestrial life. Numberless deposits were continuously laid down until the crust of the earth attained the upper surfaces which are now occupied with every existing form of life. A geological chart presents from forty to fifty strata, distinctively named for the sake of convenience; but as these represent groups of formations, the operations by means of which the strata have been laid down, have been far more numerous. For example,

the coal measures alone embrace several hundred alternated deposits. We have to picture to ourselves a long succession of continuous change and construction to account for the laminated crust of the earth, extending to a computed thickness of ten or twelve miles, for which some inconceivable period of time must be accorded. Layer after layer has been imperceptibly composed out of the decay of pre-existing elements, and brought to its position chiefly by the agency of water; to permit of which, every portion of the earth has been subjected to slow upheavals and depressions, whereby land and water have repeatedly changed places.

"The structural complexities of the earth's crust have arisen through the actions of natural causes. . . . Here and there are pointed out sedimentary deposits now slowly taking place. At this place, it is proved that a shore has been encroached on by the sea to a considerable extent within recorded times; and at another place, an estuary is known to have become shallower within the space of some generations. In one region a general upheaval is going on at the rate of a few feet in a century; while in another region occasional earthquakes are shown to cause slight variations of level. . . . But the changes thus instanced are infinitesimal compared with the aggregate of changes to which the earth's crust testifies, even in its still extant systems of strata. . . . From the small changes now being wrought on the earth's crust by natural agencies, we may legitimately conclude that by such natural agencies acting through vast epochs, all the structural complexities of the earth's crust have been produced" (Herbert Spencer, *Prin. of Bio.*, I. 352).

Mr Darwin observed on the coast line of South America a rise of coast above the epoch of the existing shells of from 400 to 500 feet, and there might, he thought, be a greater rise further inland. He was convinced that the Andes had slowly risen, and that the continent is still rising with extreme slowness. At Guasco, on the coast of Chili, there were seven parallel terraces perfectly level, but with plains of unequal breadth, occurring on both sides of a valley. "Continental elevations, as observed in South America and other parts, seem to act over wide areas with a very uniform force; we may therefore suppose that Continental subsidences act in a

nearly similar manner." There are areas of great extent which have undergone movements of an astonishing uniformity, the bands of elevation and subsidence alternating. In "the Pacific and Indian Oceans we shall find that all the *active volcanoes* occur within *the areas of elevation*. . . . Proofs of recent elevation almost invariably occur where there are active vents; I may instance the West Indies, the Cape de Verds, Canary Islands, Southern Italy, Sicily, and other places." It can be shown "that the intertropical ocean, throughout more than a hemisphere, may be divided into linear parallel bands, of which the alternate ones have undergone, within a recent period, the opposite movements of elevation and subsidence. . . . The action of volcanoes, and the permanent elevation of land, (including mountain chains,) are parts of the same phenomenon, and due to the same cause" (*Voyages of the Adventure and Beagle*, III., 411, 412, 423, 561, 567, 569, 627).

"So far as we can trace the new modifications in the distribution of land and water, the main feature seems to have been a transference of dry land from the southern to the northern hemisphere,—that is, the submergence of land in the one, and its emergence in the other. Great alternations have taken place, and are constantly taking place in this respect, everywhere. What is now above water was formerly below it, and *vice versa*, and in each hemisphere there are portions intermixed with each other, the one of which is rising and the other sinking. And we can see that both operations are carried on at the same time, and that the one is usually in compensation of the other; although both are intermingled, sometimes a general sinking with partial risings. . . . It is a generally acknowledged principle that important geological revolutions are slow and deliberate, and extend over a long period of time; that the crust of the earth is not perpetually bobbing up and down; and that the oscillations which occur in every part of the globe are mere minor accidents, as it were incidental to the progress of the great movement, and not the great movement itself. They may be compared to the slightly tremulous movement of a man's hand when he heaves his food to head; the real movement is the raising of his hand, its vibration is the incidental. One phase of these

geological mutations is the alternation of bands of elevation and depression. . . . It is matter of fact that the elevation and corresponding depression in the two bands generally lie alongside of each other. . . . It seems a necessary consequence of the elevation of dry land in the northern hemisphere, that a corresponding depression should have taken place somewhere else." The crust of the earth "is both solid and elastic" (Murray, *Geographical Distribution of Mammals*, 25, 27, 28). The rate of alteration in land levels may be as slow, Professor Huxley suggests, as but an inch or two in the course of a century (*Lectures to Working Men*, 35).

Various indications of time are drawn from features observable on the earth's surface, which help the mind to apprehend in some measure the exceeding lengthened periods required for the remoter operations traceable in the lower depths of the earth's crust, in the shape of vast accumulations and transpositions.

The ages of certain trees may be calculated by the number of their concentric rings of annual growth. A cypress tree near the city of Mexico, of eighteen feet diameter, has been estimated as 3240 years old (*Dates and Data*, 62). A baobab tree of Senegal, measuring thirty feet in diameter, is thought to be 5150 years old; and a taxodium of Mexico, measuring one hundred and seventeen feet in girth, is computed at 6660 years (Lyell, *Prin. of Geo.*, II., 44, 45; *Dates and Data*, 61).

The sediment of the Nile, measured at the statue of Rameses II. at Memphis, was found to have accumulated nine feet four inches in 3200 years. The total accumulation to the desert sand measured forty-one feet, showing that this deposition has been going on for 14,000 years (Lyell, I., 431-439). The deposits of the Mississippi at its delta are in some places more that 600 feet deep. They are variously estimated to have occupied periods up to 100,000 years (*Dates and Data*, 2, citing Lyell; *Types of Mankind*, 336).

The cutting of the Niagara, at its fall, through seven miles of hard limestone rock, is supposed to have occupied 37,000 years (Lyell, *Prin. of Geo.*, I., 358-361). But "the time necessary for the formation of the Niagara channel sinks into

insignificance when compared with that required to produce the Great Cañon of the Colorado, California. This is a narrow chasm, 500 miles in length, with perpendicular sides, varying in height from 3000 to 5000 feet, and hollowed out of the solid rock by 'the rush of the stream flowing in it, which has cut through all the sedimentary strata and several hundred feet into the granite beneath" (*Dates and Data*, 1, citing *New Tracks in North America*, by W. A. Bell).

Professor Agassiz reckons that it has required 135,000 years to form the coral reefs of Florida (Lyell, *Ant. of Man*, 44). Estimating their rate of growth at one-eighth of an inch in a year, for reefs, such as exist, of at least 2000 feet in thickness, the period of 192,000 years would be requisite (Huxley, *Critiques and Addresses*, 131, citing Dana).

At cuttings in New Orleans in the delta of the Mississippi, under an existing wood of oaks, have been found the remains of ten successive cypress forests which have replaced one another. The estimate for the whole is 158,400 years (*Types of Mankind*, 337, 338).

Kent's Cavern at Torquay has three several depositions of stalagmite flooring, ordinarily separated from one another by strata of loam, or breccia, of considerable thickness. Stalagmite is formed by droppings of water, containing a solution of lime, obtained in passing through the limestone roof of the cavern. It is laid in very thin laminæ, slowly formed, and runs to considerable depths. Such measurements as five and six feet, eighty inches, seven feet, and even twelve feet and a half, are given as the varying thickness of an individual floor (*Reports to British Association for* 1868, pp. 51, 54, 55). Some very enormous period must necessarily have been passed in the formation of these deposits.

The several features which are above in question relate only to the upper portion of the crust of the earth, the formation of which, in the estimate of geologists, is a thing of yesterday in comparison with the remoter operations of the Silurian, Cambrian, and Laurentian eras. It is only in the vaguest manner that any idea of the vast antiquity of the oldest deposits can be expressed. For example, Sir Charles Lyell would assign 240 millions of years to the Cambrian system (*Prin. of Geo.* II., 340), while Volger proposes 648

millions as the age of the oldest formation (Büchner, *Force and Matter*, 61).

Geologists have divided the strata containing organic remains into three great sections, termed the Primary, Secondary, and Tertiary periods, to which has been added the Post-Tertiary or Quaternary period. My subject does not require me to deal with the remains of the two earlier sections. At the commencement of the Tertiary epoch "there was a start given to the development of species, and new forms and new types came then into being. What the change consisted in we do not know; but it may have been some great change in the relative proportions of land and water: a change from a world almost covered with water to one with less sea and more dry land. The fact that no remains of land-animals have been found during the cretaceous epoch, and very few of terrestrial plants, while soon afterwards they become plentiful, suggests the possibility of this having been the nature of the change. Whatever it was, however, the fact seems certain that a great change did then occur, and, *inter alia,* that terrestrial life for the first time assumed an important place among created beings" (Murray, *Distribution of Mammals,* 23).

The Tertiary period, it is necessary to note, has been divided by geologists into various sections. The lowest and most ancient of these is termed the Eocene, after which come the Miocene and the Pliocene. Then occurs the period of the fluvial drift, after which is the Pleistocene, belonging to the Quaternary period in which we at present stand.

Among the various nations of the earth, none possess historical traces which reach back to so remote a period as do those of the Eastern Aryans, of whom I have treated specially in a separate work.* Their still existing classic language, the Sanskrit, is of an antiquity which may not be measured; and it points to a still earlier tongue on which it has been modelled, belonging to them at that indefinable period when they occupied their original Bactrian home. Then, in that region, they were already a civilized people, with a long prior history, before we find them overpassing their bounds and spreading themselves far and wide among less advanced races.

* The Legends of the Old Testament traced to their apparent primitive sources.

They may be recognized far south in India by astronomical tables made true for the year B.C. 3102, and on the conclusion that the zodiac is an instrument of their invention, the Egyptian zodiac of Dendera gives them an antiquity of above 17,000 years.*

The Chaldean astronomical tables reach to the year B.C. 2234. There is an Egyptian inscription of the eighth year of Sesourtesen III. of the XII^th dynasty, supposed to be of about B.C. 2200 (*Types of Mankind*, 268, citing de Rougé). And there is "a Cushite, or Hamitic inscription, found in Susiana, in which there is a date that goes back nearly to the year 3200 before Christ" (Baldwin, *Pre-hist. Nations*, 185, citing Rawlinson).

Lepsius gives the age of Menes, the first historical king of Egypt, at B.C. 3893 (Osburn, *Monumental Hist. of Egypt*, I. 232). Menes is associated with foreign conquests, public monuments, and progress of arts. A numerous population, and a long period of civilization, must, it is concluded, have preceded him; and there were, it is evident, contemporary nations with whom this martial monarch measured his strength (*Types of Mankind*, 236). Menes is said to have constructed important engineering works, diverting the course of the Nile for the protection of Memphis, and excavating a vast reservoir for the superfluous waters of the river (Osburn, I. 229, 230). The earliest of the great monumental remains of Egypt, including the pyramids of Gizeh, belong to the IV^th, V^th, and VI^th dynasties. It is noteworthy that these, the most ancient specimens, transcend in excellence the later productions, and in themselves afford evidence of anterior cultivation of art, through no inconsiderable period (Marriette Bey, *Aperçu de l'Hist. Anc. d'Egypte*, 76-78). "The perfection of Egyptian art is to be found in the monuments which are of the remotest date. The most ancient remains with which we are acquainted are those in which the largest amount of artistic and handicraft skill has been displayed. There are tombs, the decorations of which are so far beyond the range of modern art that all copies of them which I have seen give but the same faint hint at the original as one of the ordinary modern reproductions of the Venus de Medicis, or the

* The Legends of the Old Test., &c., 49, 50, 52.

Belvidere Apollo. These tombs are all of the very remotest antiquity. The deterioration from them is exactly graduated as we descend the stream of Egyptian history. With occasional and very partial exceptions, the oldest monument is the best executed, and the most recent the worst, whether we commence our researches from the source or the termination of this long river, or from any point intermediate" (Osborne, I. 209, 210). The Hieroglyphic writing of the Egyptians has undergone no changes, and appears perfected in the earliest tracings we have of it (*Ibid.* I. 418, 419). Fragments of burnt brick and pottery have been found in the alluvium of the Nile, which are thought to belong to a period corresponding with B.C. 7500 (*Dates and Data,* 27, 28). Herodotus was shown by the Egyptian priests the effigies of 343 generations of priests who had followed each other in regular succession to the time of Sethos, who was of B.C. 713. The earliest of the line, it is computed, must have been of fully B.C. 12,000 (*Ibid.* 4). The oblong Zodiac of Dendera, in the primitive position of its signs, points to an age dating 17,250 years ago, before which time there must have been a period of civilization to have led up to the use of such an instrument.*

In Denmark, beech forests are found growing on sites over the remains of more ancient forests. These consist of oaks of two varieties and Scotch firs. Implements of the polished stone, or Neolithic age, of bronze, and of iron, are met with in these localities. The beech having flourished in Denmark 1800 years ago, in the time of the Romans, the lowest of the embedded forests must have existed from 5000 to 6000 years B.C. (*The Anc. Cave Men of Devon,* 18, 19). The animal remains here found are those of existing species.

The Swiss lake habitations contain objects of the Neolithic stone age, and of the bronze age, but none of iron. Among the relics of animals are those of the Urus, which is now extinct, but existed in the time of Cæsar. The reindeer, so common in ancient times in the southern parts of Europe, was not then in this region (*Anc. Cave Men of Devon,* 23; Lubbock, *Pre-Hist. Times,* 150-152).

* The Speaker's Commentary Reviewed, 120; The Legends of the Old Test., &c., 58.

The Danish kitchen middens, or refuse heaps, lie beyond the era of metals, and contain unpolished but well-shaped stone implements, which are held to belong to the early part of the Neolithic period. The animal remains are of existing species, together with the Urus (*Anc. Cave Men of Devon*, 19; Lubbock, 181-196).

Remains of pottery have been found twenty-eight feet below the surface in Somersetshire, in conjunction with the bones of the mammoth and extinct rhinoceros (*Dates and Data*, 11). Under the second of the embedded cypress forests in the delta of the Mississippi, pottery has been discovered, and under the fourth of these forests a human skeleton, which is of the computed age of 57,600 years (*Types of Mankind*, 272, 337, 338).

In 1837 the discovery, by M. Boucher de Perthes, of celts, or flint implements, shaped artificially, in the gravel of the drift period, opened out an important source of evidence to the exceeding antiquity of the human race. A few such specimens had been brought to light in England by Mr Conyers in 1715, Mr Frere in 1800, and MM. Toornall and Christol, in the south of France, in 1828 (Lubbock, *Pre-hist. Times*, 271, 257), but though these objects were in strata, containing bones of extinct mammals, public attention was not drawn to the circumstance. Among the various localities belonging to remote periods in which the celts have been found, may be instanced an aqueous deposit of from twenty to thirty feet in thickness, in land now one hundred and sixty feet above the sea, and ninety feet above the river Somme, in a country, the surface of which has undergone little alteration since the times of the Gauls and Romans, whose sepulchres are there (*Dates and Data*, 5, note); also breccia not less than sixty feet beneath the earth's surface, and undisturbed drift gravel within six and a half feet of the chalk (*Ibid.* 9, 10).

Human remains, and other works of art, have been discovered in the same position as the celts; that is, in the drift deposits, and in contact with the bones of extinct mammals. In 1863, M. Boucher, at Moulin-Quignon, drew out a human jaw-bone from its position embedded half a yard below the tooth of a mastodon (*Dates and Data*, 5-7). In the same

year Mr Poole exhumed from the banks of the Bridgewater Level, in Somersetshire, pottery and human bones, at a depth of twenty-eight feet below the surface, with bones of extinct animals (*Ibid.* 11). In the following year M. Boucher de Perthes found a considerable number of human bones, intermixed with those of various animals, and a human jaw-bone buried twenty-five feet below the surface, beneath bones of *Rhinoceros tichorhinus* and *Bos primigenius* (*Ibid.* 7). In the same year, Dr Falconer, with MM. Lartet and de Verneuil, discovered in the valley of Vezère (Dordogne), pieces of ivory, on which was engraved the head seemingly of a mammoth. From the same valley M. de Vibraye obtained a fragment of reindeer bone, on which was engraved the head of the true elephant, differing, however, materially from the existing African and Asiatic types; and in other diggings at Dordogne and Charente he discovered, depicted on various substances, representations of a combat of reindeer, of a stag and doe, a horse, ox, otter, and beaver, all designed with artistic skill, and indicating a knowledge of the said animals in life. The fossil bones of these animals were in the same localities (Lesley, *Man's Origin and Destiny*, 258-261). In 1866, Professor Cocchi, of Florence, dug up, near Arezzo, a human skull, forty-eight feet below the surface, under the gravel and alluvium, six feet above which was the tusk of a mammoth (*Dates and Data*, 11). In 1868, M. Bertrand discovered a quantity of fossil human remains in the quaternary drift at Clichy, near Paris, in contact with bones of the mammoth, rhinoceros, and hippopotamus (*Ibid.* 11, 12).

Very abundant testimony, of vast importance, has been furnished by deposits in caverns. In 1828 and 1829 MM. de Christol and Tournal found in caves at Pondres, Souvignargues, &c. (Gard) and Bize (Aube), human bones and fragments of coarse pottery in juxtaposition with remains of the cave bear, rhinoceros, and hyena (*Dates and Data*, 35). In 1852, seventeen human skeletons were discovered in a cave at Aurignac (Haute Garonne), together with teeth of extinct mammals, and eighteen little discs of sea-shell pierced as for ornaments. In 1860, M. Lartet examined the spot. The grotto had been closed with a large upright slab of stone

which had protected its contents from the attacks of wild animals. The bones within were consequently ungnawed, and among them was the whole limb of a cave bear on which the flesh must have existed when it was deposited. There were also here human bones, flint instruments, bones and horns of reindeer shaped as awls, bodkins, arrow-heads, and whetstones, and a bird's head formed out of the eye-tooth of a bear. In earth thrown out of the grotto when the skeletons were removed were discovered a beautiful specimen of worked reindeer horn, a hundred miniature weapons in flint, fragments of pottery, and human and animal bones ungnawed. Outside, on a terrace level with the floor of the grotto, in a continuous deposit, were hearthstones, charred wood, cinders, pottery, flint tools, and arrow-heads, and burned and fractured bones of the cave bear, mammoth, rhinoceros, Irish elk, and cave lion, which had been split open by man for the marrow, and gnawed by animals. The whole gave evidence of a funerary grotto, the human remains having been deposited therein with food and miniature weapons for the use of the departed, while feasts in their honour had been held outside the cave (Lesley, *Man's Or. and Dest.*, 261-264; Lubbock, *Pre-hist. Times*, 262-265; Lyell, *Ant. of Man*, 181-193). In 1863, MM. Lartet and Christy explored ten caverns in the valley of Vezère (Dordogne), in which they found bones of extinct animals, flint implements, and bones on which reindeer and other animals now extinct were very skilfully engraved. In one instance the human figure had been represented. In 1869, M. Lartet, junior, discovered in these caves five gigantic human skeletons with bones of the mammoth, &c. (*Dates and Data*, 38). In the same year, Vicomte de Lastie disinterred in a cavern in the valley of the Aveyron (Tarne-et-Garonne) a jaw-bone, teeth, and other portions of human crania, together with implements of horn and bone on which were engraved figures of the mammoth and the head of the reindeer. In the same locality were the bones of the reindeer, cave hyena, and other extinct mammals (*Ibid.*, 38). Dr Edward Dupont, from the year 1865 and onwards, conducted explorations in twenty-four caves in the valley of the Lesse, near Dinant, Belgium, in which numerous human bones, thousands of flint implements, and a vast variety of horn and bone instruments

associated with the fossil remains of the mammoth, rhinoceros, cave hyena, cave lion, &c., were found. There were also reindeer horn instruments pierced with holes, and a paved fireplace whereon lay a mammoth's bone (*Ibid.*, 38, 39).

Kent's Cave, near Torquay, of all the caverns that have hitherto been explored, affords the most important light in relation to the age of the earth and its human inhabitants; and it has the advantage of being carefully and scientifically examined by a Committee of the British Association who have been labouring there without intermission since the year 1865. The floor of this cavern is laid out in well-distinguished strata, one deposit divided from the other and sealed up with a solid coating of stalagmite, so that the whole presents a well-ordered calendar of the ancient histories thus preserved. There are six geological deposits, namely, (1) of black mould, forming the surface floor of the cavern; (2) a floor of granular stalagmite ; (3) a stratum of red cave earth; (4) a floor of crystalline stalagmite; (5) a stratum of brown rock-like breccia ; (6) another floor of stalagmite. The cave consists of two ranges of chambers running north and south. The eastern range has been systematically examined to the depth of four feet in the red cave earth, or the third of the deposits. But in a compartment called the south-west chamber, where the two upper floors of stalagmite were in contact, operations were carried on by tunnelling in the brown breccia below, and in this way the existence of the third floor of stalagmite was brought to light. The bottom of the cavern has not yet anywhere been reached, and the western range is still unexplored. Where the superior stalagmite floors touch each other, from want of intervention between them of the cave earth, they are always distinguishable, the one being chiefly granular and the other wholly crystalline. Sometimes the crystalline floor of stalagmite is wanting, and the cave earth and breccia are in contact, but the lines of these deposits are always distinct. The relative eras of the objects laid up in the several deposits can thus always be satisfactorily distinguished, and we have consequently before us reliable records of the existence of man, and the animals associated with him, from modern and historical

times, far back to some inconceivably remote stage of antiquity.

1. The Black Mould runs from less than an inch to a foot in thickness. In it has been found "a very large and miscellaneous assemblage of natural and artificial objects, ranging from the present day back through mediæval and Romano-British to pre-Roman times." The objects are human vertebræ, jaws, teeth, and portions of skulls; charred wood; whetstones and polishing-stones; flint flakes; stone spindle whorls, plain and ornamented; fragments of curvilineal plates of slate, supposed to be covers of earthenware pottery; bone awls, chisels, and combs; bronze rings, a fibula, spoon, spear-head, socketed celt, and pin; amber beads; pieces of smelted copper; and much broken pottery, one specimen Samian (Greek), and others Roman. The human remains are very abundant, and the bones having been cut and scraped by sharp instruments, and broken for the marrow, there is room to apprehend that the inmates of this period were cannibals. The shells and animal remains all belong to existing species.

2. The uppermost, or modern floor of Stalagmite, contains small fragments of limestone cemented together with carbonate of lime, and is so compact as to require blasting. Sometimes it is hard and crystalline in alternation with soft and granular deposit. In the great chamber it runs from one to three feet in depth. In some places, where the drop is excessive, it reaches five, six, and even seven feet in thickness. It contains palæolithic flint implements, charred wood, marine and land shells, bones of existing animals, and some of those which are extinct, namely, of the horse, cave hyena, rhinoceros, and of a bear which may be the cave bear. Of human remains, there have been met with only a tooth and a portion of an upper jaw containing four teeth, which were deeply embedded in the stalagmite, here twenty inches thick.

3. The Red Cave Earth is composed of angular pieces of limestone, and occasionally rounded stones not belonging to the cavern hill, mixed in with earthy deposit. In the north entrance chamber, termed the vestibule, under the stalagmite, either touching it or removed from it by intervention of from three to six inches of cave earth, was a layer of black soil, covering an area of about one hundred square feet, to the

depth of from two to six inches. This is termed the Black Band, and is of the same character as the black mould above the stalagmite. This place was extremely rich in objects, and contained remains of ox, deer, horse, badger, bear, fox, rhinoceros tichorhinus, and cave bear; palæolithic flint implements, chips, and flakes; bones partially burnt, and charred wood in great quantities; bone tools, consisting of an awl, a harpoon barbed on one side, a needle with a well formed eye, and a nondescript instrument. In this part of the cave, it is conjectured, the cave men dwelt and had their fires. The cave earth is well stocked with bones of extinct animals, which increase in frequency in the lower levels. These remains are of the cave bear, grizzly bear, cave lion, cave hyena, fox, horse, ox, deer of several species, Irish elk, reindeer, beaver, tichorhine rhinoceros, and mammoth. Mixed up with these are palæolithic flint and chert implements, and there are also pieces of burnt bone and rounded stones not belonging to the hill formation. One of the latter is judged to be part of a whetstone. A foot deep in the cave earth was a bone harpoon, barbed on one side. Beneath the black band, two feet down in the cave earth, was a highly finished bone harpoon, barbed on both sides; and in the fourth foot below the stalagmite, in contact with the molar of a rhinoceros, was a well finished polished bone pin, three and a half inches long, which it is supposed was an article of toilet.

4. The second floor of Stalagmite. This is in thin laminæ, showing it has been deposed slowly, and is formed into prismatic crystals. At the tunnelling called the Water Gallery, and in parts called Smerdon's Passage and the Sloping Chamber, it is *in situ*, and in the latter place is sometimes as much as twelve feet thick. In other places it has been found broken up, sometimes in large fragments which are incorporated with the cave earth and modern stalagmite floor, and projecting a foot beyond the superficial black mould, and measuring three or four cubic yards. Many of these fragments contain bones and teeth, but of the cave bear only.

5. The Brown Breccia. This consists of pieces of rock compressed together so as to form a firm compost of the solidity of rock. It was found *in situ* at the water gallery,

and there, in the first foot level, was obtained a small angular chip of flint; and two or three feet down in the breccia was a flint which has been carefully examined by an expert, and is considered to have been shaped by human hands. Two other flint implements, according to a later report, have been found in other parts of this deposit, at depths in it of from one to two feet; and by the last report, presented to the British Association in September 1873, we learn that seventeen more such implements have been therein discovered, which "are of a far more archaic character than those found in the cave earth" (*The Times* of 26th September 1873). In various places the breccia has been broken up in masses, and is full of remains of the cave bear. These bones have no marks of having been rolled, broken, or gnawed, and, as they lie together without the least reference to their anatomical relations, it is not apparent how they have been introduced into the cave. The other extinct animals, such as the cave hyena, the cave lion, the mammoth, rhinoceros, and horse, have no *reliquiæ* in this deposit. The cave bear has thus for long ages, in this region, had precedence of the other extinct animals, and, on the testimony of the flint implements, man, at that remote period, was his contemporary.

6. The lowest Stalagmite Floor. The rock-like breccia contains considerable pieces of stalagmite, which give evidence of a floor deposed below it. Some of the pieces are of great size, but no foreign objects are spoken of in connection therewith.

All through the various deposits of the cavern, and on the upper surface of its soil, occur blocks of limestone, torn down from the roof or sides of the cavern by some unknown force. These are of all ages, and some are of huge size—one being estimated at as much as thirty tons.

The peculiar testimony of Kent's Cavern is amply supported in other directions. There are two distinct floors of stalagmite in the Windmill Hill cave at Brixham, as I am informed by Mr Vivian; in Poole's Cavern, Buxton, as appears in the account thereof by Mr Redfern, the proprietor; in the caves of the Wye (*Times*, 6th March 1874), and in the cavern called Trou de la Naulette, near Dinant, in Belgium

(*Dates and Data*, 39). Single floors occur, I believe, very frequently, and perhaps universally, in limestone caverns; and that successive ones have not been more frequently brought to light, is due probably to want of sufficient exploration, or the shallowness or modern formation of the caverns. Under the stalagmite depositions of caves which have been examined, remains just such as have been met with in Kent's Cave have been obtained. So far back as before the year 1774, deep in the soil under the stalagmite floor in the caves of Gailenreuth, in Franconia, were found human bones and fragments of rude pottery, in company with the osseous remains of cave bears and cave hyenas. Dr Buckland visited these caverns in 1816 and 1824 (*Dates and Data*, 34). In the caves of Kostritz, in Upper Saxony, Dr Schotte and Baron von Schlotheim discovered human bones in ossiferous loam, at a depth of twenty feet, under a crust of dense stalagmite, some of which were embedded eight feet beneath the remains of a rhinoceros. These explorations were reported on in 1848 (*Ibid.* 35). In 1853 Professor A. Spring found five human jaw-bones, a parietal bone, and a flint hatchet, in a breccia floor, below several feet of cave earth, having a crust of stalagmite, in the Caverne de Chauvaux, near Namur, Belgium. The human bones were in contact with those of the eland, auroch, and other animals, many of which were artificially split (*Ibid.* 36). The two layers of stalagmite in the Trou de la Naulette, before spoken of as a cavern in Belgium, alternate with stratified beds of clay. In a deposit of sandy clay, below the lowest of the stalagmite floors, at a depth therein of three metres and a half, were found a human jawbone, two teeth, and an arm-bone, with the fragment of a reindeer horn, which apparently had been bored by some sharp instrument (*Ibid.* 39).

The positive evidence of the existence of human remains below a second floor of stalagmite, furnished by the cavern last mentioned, assists us in accepting, as human relics, the flint implements found in a like position in the breccia of Kent's Cavern. The occurrence of human remains and works in the gravels of the drift period places man on earth before the quaternary age. The second floors of stalagmite, below which we have proofs of his being, were, it is probable, deposed

anterior to the drift. And that man lived on earth far onwards, during the Tertiary period, there is other distinct evidence.

In 1827 Captain Elliott and Dr Meigs discovered several hundred human skeletons at Santos, in Brazil, in calcareous tuff rock, containing serpulæ and other marine shells, and covered with soil bearing a growth of large trees. In 1844 a fossil human skeleton was found by M. Aymard, at Denise, near Le Puy, in France, in volcanic tuff, in company with bones of hippopotamus and cave-bear. And in the museum of Quebec is a fossil human skeleton, which was dug out of the solid schist whereon the citadel of that place stands. All these have been thought by competent authorities to belong to the Tertiary formations (*Dates and Data*, 13).

In the upper Pliocene strata at Prest, near Chartres, M. Desnoyers and the Abbé Bourgeois found bones of *Elephas meridionalis* and *Rhinoceros leptorhinus* engraved with figures of animals. The circumstance was reported on in 1867 (*Ibid.*, 12).

In 1867, Mr James Watson discovered portions of a human skull at Altaville, near Angelos, Calaveras County, California, imbedded in a stratum of undisturbed tertiary, in a mining shaft, at a depth of 130 feet below the surface. Above this there lay four beds of volcanic tuff, alternating with deposits of gravel, whereof one was 25 feet thick. The base of the skull was incorporated with a mass of bone breccia, and other parts were covered with an incrustation of carbonate of lime (*Ibid.*, 12, 13).

In the records of the Geological Survey of India for 1868, Dr Oldham has described an agate flake of human workmanship found by Mr Gwynne in undisturbed Pliocene deposits of the Upper Godavery (*Ibid.*, 13).

Bones engraved with figures of animals have been found in the Pliocene at Calle del Vento, near Savona, by M. Issel, and in the Miocene strata of Selles-sur-Cher (Loire-et-Cher) by the Marquis de Vibraye. These explorations are reported in 1868 (*Ibid.*, 12).

The following important communication, made by Mr Frank Calvert through Sir John Lubbock, appears in the *Journal of the Anthropological Institute* for April 1873 (p. 127):—

"I have had the good fortune to discover, in the vicinity of

the Dardanelles, conclusive proofs of the existence of man during the Miocene period of the tertiary age. From the face of a cliff composed of strata of that period, at a geological depth of eight hundred feet, I have myself extracted a fragment of the joint of a bone of either a dinotherium or a mastodon, on the convex side of which is deeply incised the unmistakeable figure of a horned quadruped, with arched neck, lozenge-shaped chest, long body, straight fore-legs, and broad feet. There are also traces of seven or eight other figures which, together with the hind quarters of the first, are nearly obliterated. The whole design encircles the exterior portion of the fragment, which measures nine inches in diameter and five in thickness. I have also found in different parts of the same cliff, not far from the site of the engraved bone, a flint flake and some bones of animals, fractured longitudinally, obviously by the hand of man for the purpose of extracting the marrow, according to the practice of all primitive races.

"There can be no doubt as to the geological character of the formation from which I disinterred these interesting relics. The well-known writer on the geology of Asia Minor, M. de Tchihatcheff, who visited this region, determined it to be of the Miocene period; and the fact is further confirmed by the fossil bones, teeth, and shells of the epoch found there. I sent drawings of some of these fossils to Sir John Lubbock, who obligingly informs me that having submitted them to Messrs G. Busk and Jeffreys, those eminent authorities have identified amongst them the remains of dinotherium, and the shell of a species of melania, both of which strictly appertain to the Miocene epoch.

"In addition to these discoveries, and at about ten miles distance from the above locality, I have lately come upon other traces of man's existence in drift two or three hundred feet thick, underlying four or five hundred feet of stratified rocks. I cannot positively affirm that this formation is likewise Miocene, the fossil shells it contains not having yet been examined scientifically; but in all probability such will prove to be the case. Throughout this drift I have found numerous stone implements, much worn. Flint is comparatively rare, but other hard stones have been adopted, jasper, of red and

other colours, being predominant. Some of the implements are of large size, and weigh upwards of nine pounds."

Mr Calvert then notices the discussions held on the assumption of man's antiquity being possibly measurable by about one hundred thousand years, and adds, "The remarkable fact is thus established beyond a question, that the antiquity of man is no longer to be reckoned by thousands, but by millions of years."

The phenomena before us, and especially the features of Kent's Cavern, give evidence of changes occurring in the circumstances of the earth whereby corresponding variations have arisen in the character of the deposits laid upon its crust. Had there been no alteration of the conditions of the earth, its surfaces would have incurred no other change than what length of time, or pressure, might effect. But the surface deposits have undergone marked and decided transitions, which bespeak corresponding changes in the operating causes to which the condition of the deposits is due. Wherever, for example, a stalagmite floor has been deposed upon a lower earthy stratum, there is evidence of this change. The earthy stratum has existed without its stalagmite covering. Then something has occurred to bring down the drip and effect the deposition of the stalagmite. Where there are two such coatings, as we see in several instances, and where there are three, as in Kent's Cave, there is proof of some very decided recurring cause, which at one time has arrested the drip, and at another has set it free. The thickness of the stalagmite floorings denotes long maintenance of their inducing circumstances.

The coal measures afford a like testimony. They consist of numerous deposits of the vegetable substances which have been converted into coal, between which intervene beds of shale and clay-slate. In Coalbrookdale there are 90 such alternations. In Dudley there are seams of coal of from 30 to 45 feet thick, divided into numerous strata by intervention of very thin layers of clay-slate. The Saurbrücker coal, according to Humboldt, has 120 beds superposed on one another, exclusive of a great many less than a foot in thickness. Some seams are from 30 to 50 feet thick (*National Encyclopædia*). The coalfield of Cumberland, Durham, and

Northumberland, has about 147 different strata, the coal alternating with limestone, sandstone, and clay-slate (*Penny Cyclopædia*). In the Hainaut (or Mons and Charleroi) basin, the measures are 9,400 feet thick, with 110 seams of coal; in the Liége basin, 7,600 feet, with 85 seams; and in Westphalia, 7,200 feet, with 117 seams (Mr Prestwich in *Nature*, V., 472). The coal represents exuberant fertility, and the shale and clay-slate absolute sterility, both maintained for considerable periods. "Every foot of thickness of pure bituminous coal implies the quiet growth and fall of at least fifty generations of Sigillariæ, and therefore an undisturbed condition of forest growth through many centuries" (Huxley, *Critiques and Addresses*, 106, citing Principal Dawson).

The indications of ice having prevailed over parts of the earth now possessing a warm temperature, and the occurrence of fossils of tropical and sub-tropical plants embedded in the present frigid zone, give similar evidence of marked changes in the condition of the earth. Mr Andrew Murray, in his work on the *Geological Distribution of Mammals*, has a map laying down the positions in which glaciers are found to have at one time covered portions of the earth. In North America the line reaches from Lat. 34° N. to 31° N. In South America it runs along the line of the Andes across the Equator to 2° N. In Europe it is a varying line, sometimes reaching to 50° N.; and it embraces detached mountainous regions, such as the Alps, the Caucasus, the mountains of Asia Minor, Thibet, and Nepaul, extending as far as 27° N. It is assumed, ordinarily, on negative evidence, that the ice reached only certain limits north and south, and did not occur within the tropics, except where favoured by high mountain tops, but I have seen vast boulders on the plains of Bellary, and at the Sacrifice Rocks out at sea on the coast of Malabar, which appear to be evidences of glacial transference; and a correspondent of mine, who is a competent scientific observer, has found similar signs of glaciers on the table land of Mysore, the low levels of Chittoor, and at St Thomas's Mount in the immediate neighbourhood of Madras,—these observations extending to what are now very hot localities, on moderate or low levels, within thirteen and eleven and a half degrees of the equator.

The domination of the ice was no mere passing visitation. "The glacial period, as measured by years, must have been very long." "We have excellent evidence that it endured for an enormous time, as measured by years, at each point" (Darwin, *Or. of Spec.*, 404, 407). Sir Charles Lyell describes it as of "vast duration" (*Ant. of Man*, 365). "It lasted for thousands, if not hundreds of thousands of years" (*Prin. of Geo.*, I. 212). Mr Murray also speaks of it as prevailing "for thousands and thousands of years" (*Dis. of Mam.*, 31). Geologists agree that this epoch occurred at the close of the Pliocene era. But there were previous such epochs. "We have good evidence," says Mr Croll, "of at least three ice periods since the beginning of the Tertiary period—one about the middle of the Eocene period, another during the upper Miocene period, and the third and last well-known glacial epoch." He also speaks of glacial marks occurring in the Cretaceous and Permian deposits (*Phil. Mag.* for Nov. 1868). "In lectures and print," says Prof. Ramsay, "I have frequently stated my belief that the brecciated sub-angular conglomerates and boulder beds of the Old Red Sandstone of Scotland and the North of England are of glacial origin. . . . Respecting Permian times I attempted in 1855 to prove the existence of ice-borne boulder beds during part of that epoch, and by degrees this opinion has been more or less adopted" (*Nature*, V. 64, 65). The ice-borne boulders have left their testimony behind them in unsuspected quarters. "The strangest of all places," observes Mr Milton, "to find these boulders, is at the bottom of mines." Many have been discovered deep below ground, but lately Mr Salmon gave an account of some found at seventy-four fathoms, or four hundred and forty-four feet below the surface" (*Stream of Life on our Globe*, 71).

"The prevalence of tropical heat, in past times, in the Arctic zone, is equally well recognized. The coal measures are composed of conifers, palms, ferns, tree-ferns, club-mosses, araucariæ, &c., often of gigantic growth. Such a vegetation requires long sustained warmth, and would be unequal to combat with even an ordinary wintry climate. "The same gigantic coniferous and filicoid plants are found alike in the coalfields of Britain, America, Melville Island, and Australia

—regions at once tropical, temperate, and Arctic" (Frith, *Mys. of Life*, 233, citing Page's *Advanced Text Book*). Fossils of these products were found by Captain Parry in Melville Island, in lat. 75° N.; they have been met with also in Bear Island in lat. 74° 36′ (Lyell, *Prin. of Geo.*, I. 225). "The trunk of a white spruce tree was dug up by Sir E. Belcher near Wellington Sound in lat. 75° 52′ . . . and the remains of an ancient forest were discovered by Captain M'Clure in Bank's Land, in lat. 74° 48′. . . . . Evidence of ancient forests was found in Patrick's Island, and in Melville Island, one of the coldest spots perhaps in the northern hemisphere" (Croll, *Phil. Mag.* for Nov. 1868). The coal measures of Melville Island have displayed a "noble scene of luxuriant and stately vegetation," a region where at present there are ninety-four days in the year when the sun is never seen, and one hundred and four when he never sets, having maintained plants requiring for their possible existence a diurnal alternation of light and darkness (*Penny Cyclopædia*). "We must remember that the Polar climate at the time was genial. Frost and snow were unknown, and the northern district of Iceland, and several parts of the Arctic lands, such as Disco Island on the west coast of Greenland, lat. 70° N., although at the present time entirely without trees, were densely wooded in the Tertiary period. Fragments of trees are preserved in the lignite or 'Surturbrand' of Iceland, and as they are still covered with bark they cannot have reached it as drift wood" (Murray, *Dist. of Mam.* 34).

The warmth of climate in the arctic zone has also been a recurrent circumstance. Wherever there are coal seams, as in Melville Island, there is evidence of the alternations of fertility and sterility. Shells, such as are now met with no further north than the Mediterranean, have been found in the Pliocene strata of Britain; such as belong now to Senegal, on the west coast of Africa, occur in the Upper Miocene of France; and fossil palms, and about eighty other sorts of plants which could not stand the measure of winter prevailing in the central and southern parts of Europe, have been found in Iceland in the Lower Miocene strata (Lyell, *Prin. of Geo.*, I. 199-203). "In Spitzbergen, in lat. 78° 56′ N., no less then ninety-five species of plants are described by Heer,

many of them agreeing specifically with North Greenland fossils. In this flora we observe Taxodium of two species, a hazel, poplar, alder, beech, plane tree, lime (*Tilia*), and a potomogeton, which last indicates a fresh water formation, accumulated on the spot. Such a vigorous growth of fossil trees, in a country within 12° of the pole, where there are now scarcely any shrubs except a dwarf willow and a few herbaceous and cryptogamous plants, most of the surface being covered with snow and ice, is truly remarkable. . . . We cannot hesitate to conclude that in Miocene times, when this vegetation flourished in Spitzbergen, North Greenland, and on the Mackenzie river, as well as Bank's Land, and other circumpolar countries, there was no snow in the arctic regions, except on the summit of high mountains, and even there perhaps not lasting throughout the year" (*Ibid.* I. 203, 204). "Again, in the Lower Eocene strata, we find in the London clay of the Isle of Sheppey, fossil fruits of the cocoa-nut, screw pine, and custard apple, reminding us of the hottest parts of the globe; and in the same beds are six species of nautilus and other genera of shells, such as Conus, Voluta, and Cancellaria, now only met with in warmer seas. The fish also of the same strata, of which fifty species have been described by Agassiz, are declared by him to be characteristic of hotter climates; and among the reptiles are sea snakes, crocodiles, and several species of turtle" (*Ibid.* I. 205). "Mr Bowerbank has described no fewer than thirteen fruits of palms from the Eocene beds in the Island of Sheppey, all of the recent type, now found only in India, and in the Moluccas and Phillipine Islands" (Murray, *Dist. of Mam.*, 24). With these indications before us of a high temperature having subsisted in the various strata of the Tertiary period, and in the carboniferous age, it is presumable that the intermediate and other strata of the earth have been similarly circumstanced. That a high degree of warmth also occurred in the Quaternary period is apparent. "No tree now grows in Orkney or Shetland, the only ligneous things that do grow are the *Betula Alba* and the common juniper, both merely existing as shrubs; but at six feet beneath a peat bog, trees, branches, leaves, and cones, ascribed to the silver fir, have been found—one tree in particular of six feet

in circumference, and forty feet in height, being recorded by Mr Edmonston as having been found in Shetland. When did these trees grow, and what was the climate of Britain then? Was it really milder then than now, as we should be inclined to expect, from the fact of these trees being found in Shetland, where they will not now grow? As to the date of their growth there, there can be very little doubt that it was subsequent to the glacial epoch. The grinding of the ice of that time would sweep away every trace of peat bogs from the surface of the land. Were a Swiss glacier to meet a peat bog in its course, it would soon plough it up, and scarify the ground to the very bone below. It is plain, therefore, that the tree must have grown and died, and the peat been deposited, subsequent to the glacial epoch" (Murray, *Dist. of Mam.*, 40). We have here, therefore, three alternations of climate demonstrated after the region had parted with the warmth occurring in the Pliocene era, namely, the glacial epoch, a return to a high temperature, and the present low temperature unfavourable to the growth of large vegetation.

Colonel Drayson suggests that the alternation of layers of flints with chalk may mark epochs created by the climatic changes which the earth, by its change of position relatively to the sun, undergoes. In Shakespeare's Cliff at Dover, and in Flamborough Head, above two hundred layers of flint have been counted (*Last Glacial Epoch*, 170).

The successive imbedded forests of Denmark and the Mississippi probably owe their origin to the same cause. The warmth has favoured the growth, the arctic temperature has destroyed it, and the repassing of the earth into a warm temperature has induced a fresh growth.

Various have been the efforts made to account for the very decided alterations of climate, the recurrence of which has been unmistakeably recorded on the surfaces of the earth. The variation in the ellipticity of the earth's orbit; a possible change of climature incurred in the progress of the whole solar system through space; altered relations of land and water; even a possible deflection of the Gulf Stream in its course, have been suggested as causes of these great phenomena; but it is generally agreed that they are one and all inadequate to explain the features which have to be accounted

for, so that the whole question remains one still open to consideration.

If appeal to the actualities of experience may be permitted to guide us in judging how the same portion of the globe has been for ages at one time under a continual load of ice, and at another producing a luxuriant growth of vegetation, requiring tropical heat and freedom from wintry cold, we can but ascribe the cause to the absence or presence of solar heat, which, invariably to our senses and observation, regulates these conditions. To imagine such changes in the circumstances of the earth, irrespective of the action of the sun, is to violate all probability, to subvert the known regulations of the terrestrial system, and to make our planet, in its extremest state independent of its governing orb. Nothing, in consistency with the existing ordering of what affects the earth, it is right to conclude, can have produced the great climatic changes marked upon its surface, but the subjection of the portions so affected to those alterations of position relatively to the sun, which would naturally induce such changes. These places have in one age been so situated that the sun's rays have fallen upon them imperfectly, or not at all, and in another they have received those rays continuously in direct vertical power. The arctic, or polar features, when they have occurred, have been due to a polar position, and the torrid features to an equatorial one. From this conclusion there is really reasonable escape. The one circumstance standing opposed its reception is that astronomers have not detected those geographical changes in the earth, relatively to its poles and equator, which such a proposition involves. The question is, whether the science of astronomy has been prosecuted with sufficient advantages, for an adequately lengthened period of time, to make it certain that no movement to which the poles of the earth could be subjected, of whatever slowness in measure, can be occurring, without having come under observation.

The earth, it is apparent, is subject to other changes of position relatively to the sun than are involved in its diurnal rotation and annual orbit. There are two ascertained variations which denote further change. One is the continual alteration of a line drawn through the centre of the sun to the constella-

tions mapped out on the zodiac, by which there is a constant apparent passage of these stars, as measured at the equinoxes, so that, in time, the circle of these constellations undergoes an entire revolution relatively to the sun at the equinoxes. This is called the precession of the equinoxes, and it occupies a period computed at about 25,870 years (Guillemin, 456). The movement is attributed to a perturbation of the earth by the sun and moon acting upon its bulge, or wider diameter, at the equator, whereby the poles of the earth are drawn out of course, and pass through a circular movement in a wavy or nutatory line. The other indication is the continual alteration of the angle formed by the equator with the ecliptic, the angle being said to diminish at the rate of forty-eight seconds in a century. Some connect this movement with the equinoctial one, and some hold the two to be independent.

In 1827, Mr S. A. Mackey, of Norwich, in a work on Mythological Astronomy, accounted for the climatic changes of the earth by an astronomical movement. He held that the course taken by the poles of the earth in effecting the precession of the equinoxes was not truly circular, but spiral, the poles altering their position by four degrees at each revolution of the equinoxes. He assumed a round period of 25,000 years for the said revolution, whereby, at a change of 4° at each revolution, he obtained a cycle of 2,200,000 years for the complete rotation of the poles. Elsewhere he estimated the precessional revolution at 25,700 years. Mr Mackey cited Indian information in support of his conclusions. "The Hindoos," he stated, "had also observed the angle of the pole to vary four degrees each revolution of the equinoctial points" (112). Herodotus also, he notices, reported "that the Choen, or men of learning in this country (Egypt), informed him that the pole of the earth and the pole of the ecliptic had formerly coincided" (30). Again, Berosus, it appears, told Calisthenes "that 403,000 years before his time, the axis of the earth was parallel to the plane of the equator" (80), meaning, apparently, that the axis of the earth and the equator had changed positions. "The pole of the earth," alleges Mr Mackey, "will unite with the pole of the ecliptic in about 200,000 years, which union will produce universal spring" (15[illegible]). "In all this vast portion of the earth," he

concludes, "we have found the remains of an ancient knowledge, which proves in the most satisfactory manner, that the poles of the earth were formerly in the plane of the ecliptic, and that they have been separated from it by a slow progressive motion—by a spiral recession which, at once, in our time, produces that effect which we call the precession of the equinoctial points, and the diminution of the angle of the ecliptic with the equator" (174). The Hindú doctrine of the recurrent dissolutions and creations of the earth (Manu's *Institutes*, i. 52-57; Muir, *Sansk. Texts*, III., 304), which we are accustomed to attribute to mere fancy, may prove to be based upon solid foundations. Certainly it consists, very remarkably, with the phenomena of which only in modern times we have become conscious in Europe, namely, that the earth has at periods received the death stroke of glacial sterility, and at others has revived and been clothed with the exuberant products of tropical fertility.

Mr Mackey was a practical astronomer, and Mr J. E. Mayall of Brighton, who is also a proficient in the science, has endorsed his opinion in a paper on Volcanic Theories read by him before the Naturalists' Society of Brighton, in January 1870. These views I followed in my section on the Age of the Earth in my *Speaker's Commentary Reviewed*, and now recur thereto, but in a modified and amended form.

In the past year, Lieutenant-Colonel Drayson has published a work on *The Last Glacial Epoch of Geology*, in which he offers a solution of the climatic changes which are in question on astronomical grounds. Colonel Drayson disputes the current idea that the precession of the equinoxes is effected by the movement of the poles in a circle which has for its centre the pole of the ecliptic, the radius of which is 23° 28′. The continual diminution of the angle of the ecliptic, he points out, shows that the poles and the ecliptic have a varying, not a corresponding course (105, 111, 116). He therefore suggests that the centre of the required circle is a point removed 6° from the pole of the ecliptic, and with a radius measuring 29° 25′ 47″, whereby the precessional cycle is extended to 31,840 years (127, 137, 141). By means of a diagram, it is explained that at the half of this period, or every 15,920 years, the poles of the earth are brought into

such a position as to induce a glacial temperature in winter, alternating with a tropical one in summer, in all places situated, as is England, within a latitude of 54° 34′ N., and in a parallel position to the south (145, 247, 256). This, Colonel Drayson holds, satisfies the conditions of the case, as glacial marks have not been traced further south in Europe, though in America they have been observed as far as 38° N. lat. (17, 281-283).

Colonel Drayson's remarks and conclusions, if entitled to weight, make it apparent that the great question before us, what are the movements of the earth, exclusive of its diurnal rotation and annual course round the sun, on the proper understanding of which the climatic changes it undergoes depend, is a matter still involved, in its essential particulars, in uncertainty.

The axis of rotation, Colonel Drayson maintains, never alters relatively to the earth, but changes its direction as regards external objects at the rate of 20″ annually, or 1° in about 180 years (101, 103, 192). One effect of this circumstance may be that the movement described by the poles may possibly not be a circular one (116, 216), a result which would favour Mr Mackey's theory of a spiral movement. Colonel Drayson makes the circumstance, however, consist with his circular movement, which, if accepted, throws the precessional movement, as currently estimated, out of the field.

The received theory that the change in the angle of the ecliptic is caused by a change in its plane, he disputes, observing that if, as held, the poles of the earth move in a circle whereof the pole of the ecliptic is the centre, no alteration of the plane of the ecliptic would alter its angle (92).

The theory of La Place respecting the change of the angle as caused by a change of the plane of the ecliptic, (which Herschel has adopted,) is that it is an oscillatory movement confined to the limits of 1° 21′ on each side of a mean position. More recently, however, Leverrier has laid it down that it extends to 4° 3′ (91, 92, 234). The present rate of the decrease in the angle, Colonel Drayson considers to be 45″ per century (115); but, taking the ordinarily stated rate of 48″, La Place's movement over 2° 42′ would occupy

20,250 years, and Leverrier's, over 8° 6′, would require 40,500 years more, before the supposed retrogression of the plane would take place. If, then, the movement may possibly advance so far beyond the limits at which La Place has conceived a retrogression is effected, possibly there is no such retrogression at all, and the movement is not an oscillatory but a continuous one. Colonel Drayson accounts for the change in the angle by means of a totally different cause, namely, the peculiar circular movement of the poles of the earth which he advocates (92).

Colonel Drayson thus disallows the received elements of the precessional movement before us, saying that, "up to the present time the true course of the pole has never been known" (132). This is a judgment to which I feel warranted to subscribe, as, wherever I have presented the particular theory I have been led to adopt in view of the climatic changes of the earth, I have been given to understand that there is nothing yet so positively ascertained in the realms of astronomy as to contradict my conclusions absolutely.

Mr Mackey's proposition involves a constant revolution of the poles; the north pole, for example, being brought to the present position of the equator, then to that of the south pole, then again to that of the equator, and finally recurring to its original place. But such changes would merely induce extremes of heat and cold, in summer and winter, in the polar and adjacent regions, while the necessities of the case call for long maintained alternations of the contrasted temperatures; and this is an objection equally fatal to Colonel Drayson's theory, which secures no more than hot summers and severe winters in the quarters of the globe which are with him in question.

But if, as appears to have been the case, ice capable of conveying huge boulders has prevailed on the eastern coast of India to 13° of N. lat., and on the western to 11° 30′, there is an extent of glacial action which Colonel Drayson has not contemplated, and for which the astronomical movement he projects makes no provision. He leaves to the tropics the climate they now possess, whereas this quarter of the globe would seem, equally as the polar parts, to have been at one time under a heavy coating of ice.

Glaciers are known of, formed of ice "in some cases thousands of feet in thickness." They are met with in Greenland, "at the very least, 3000 feet in thickness." Those of the Alps, in the glacial period, were "on an immensely larger scale than at present." "The lowlands were covered with a universal coating of ice, probably as thick as that in the north of Greenland in the present day" (Drayson, 12-18, citing Professor Ramsay). We can form some idea of these masses from the fragments which detach themselves from them and float in the sea as icebergs. One has recently been observed, stranded on the coast of Newfoundland, which, after being some considerable time at sea, exposed to summer heat, had an estimated thickness of 280 feet (*The Times* of 22d August 1873).

The masses of rock borne upon these glaciers over extensive distances are evidence of their great expanse and solidity. The pedestal of the statue of Peter the Great is one of these, the weight of which is computed to be 1500 tons. The Needle Mountain in Dauphiny, measuring 1000 paces in circumference at the top, and 2000 at the base, is supposed to be another. Other specimens are mentioned of forty feet by fifty, weighing 3,800,000 pounds; of 1200, 2250, and 10,296 cubic feet; of 27,000 cubic feet, weighing not less than 2310 tons; of 8000 cubic feet, and weighing 680 tons; and in conglomerate of an estimated weight of as much as 5400 tons. "The instances are endless that might be given of similar large and insulated masses now lying at a remote distance from the parent rocks from which they have been abstracted" (Drayson, 55-57). In Sutton Common, Craven, is one of about fifty yards in circumference, and ten yards in height. In Canada "huge granite boulders" "lie strewed like the wreck of some mighty city of old" (Milton, *Stream of Life on the Globe*, 72, 73). "Solid packs of ice," it is suggested, "nine and twelve hundred feet high, and miles long, could have borne any number of these rocks" (*Ibid.* 74). Those seen by me in the district of Bellary, and on the coast of Malabar, were of great size and weight, as large as ordinary buildings. The glaciers of the ancient days, which were capable of bearing and conveying these ponderous masses, have left proportionate moraines, or rubbish heaps, scored up in their passage.

These are "on a scale so immense that the largest forming in the Alps in our time are of mere pigmy size when compared with them" (Drayson, 17). In Canada, "when the ice retired, it left a bed of drift, five to eight hundred feet deep" (Milton, 73); and boulder clay is met with, running to seventy and eighty feet in thickness (*National Encyclopædia*). These vast glacial effects could not possibly have been produced by winters, of whatever severity, interrupted by summers bringing with them torrid heat. They necessitate long sustained cold, unchecked by serious heat, as in the present polar regions, where ice dominates through all seasons of the year, and geologists have consequently been satisfied that the true glacial epochs are to be measured by ages.

The prevalence of the heat when places now in the arctic zone were covered with luxuriant foilage, equally requires the element of long continuance. The tropical plants of the coal measures, which are frequently of large proportions, could not have been produced in countries subject at the time to arctic winters, or cold of any marked degree of severity. Colonel Drayson's astronomical movement would only secure a tropical temperature as far as 30° 30′ N. lat.; but it is required to have extended forty degrees higher up at Melville Island, Bear Island, and Wellington Sound. He has also failed to explain how an arctic position extending to 54° 34′ can have secured a glacial epoch in America sixteen degrees still farther south.

Nothing, therefore, will adequately account for the effects of climate before us, but such an alteration in the relations of the earth's surface to the sun, as may bring any given locality at one time to the position of those places which we see now covered with ice in the vicinity of the poles, and at another to that of those clothed with luxuriant vegetation in the neighbourhood of the equator. Like effects, we have the right to assume, have been produced by like causes.

To effect the requisite geographical changes of the earth relatively to the sun, it is apparent that the earth must be constantly altering its position with respect to its poles. Either the mass of the earth is always, however slowly, moving away from its poles, or the polar axis is slowly altering its position across the earth.

The first circumstance to be understood is what constitutes the rotating axis of the earth; or, in other words, what is the power which makes the earth revolve on an axis? Here the astronomers have hitherto failed to supply us with any solution. It may be deduced, I have been informed, from Prof. Farraday's views, that the rotating power is magnetism directed on the earth by the sun; and there is assuredly much to support such an idea. The sun's rays will restore the power of a weakened magnet, and an iron key exposed to them has been converted into a magnet (Reichenbach's *Researches*, 145). An iron ship under construction is sensibly affected by magnetic action directed upon it, presumedly, by the sun. Every such vessel has a power of its own to influence the compass, termed its local variation, and the character of this variation depends on the position in which the vessel may have been originally constructed. That is, a vessel laid down, when being built, in the direction of the poles, north and south, will have a specific local variation, and one laid down in the direction of the equator, east and west, will have a different local variation. And these specific characteristics will belong to the several vessels ever after. It is apparent, therefore, that the vessels have become magnets, but with properties varying according to the direction of the currents which have magnetized them. I have this information from a reliable source. The human body is similarly affected. Sensitive persons suffer a disturbance when sleeping in the line of the magnetic equator, which does not occur when they are in the line of the magnetic poles. "Terrestrial magnetism has been clearly shown to be influenced directly by the action of the sun" (Proctor, *Light Science for Leisure Hours*, 6). Farraday ascertained by experimenting on a diversity of substances, mineral, vegetal, and animal, that all are in various degree amenable to magnetic influence (Tyndall, *On Diamagnetism*, &c., xii). The intensity of the magnetic action, General Sabine has found, varies according to the nearness of the earth to the sun in its orbit. It is greatest in both hemispheres in December and January, when the earth approaches nearest to the sun (Proctor, *Light Science*, 32). What are called magnetic storms are now attributed to solar agency. The aurora has been found "associated in some

mysterious way with the action of the solar rays" (*Ibid.* 71). Baron Reichenbach made some interesting experiments in relation to this fact. By means of the observations of sensitive persons, he found that the ends, or poles, of magnets, emit luminous matter, of which he gives several drawings, and this suggested to him "the key to the explanation of the aurora borealis" (9-19). He gathered the sun's rays on metal plates, and, on conducting a wire attached thereto into a darkened chamber, luminous flames were there exhibited as from the magnet (147, 148). Finally he suspended a hollow globe, made of sheet-iron, through the centre of which was adjusted a magnetic coil, the opposite ends of which were charged by means of wires attached thereto from a strong battery. The globe was to represent the earth, and the magnetic coil its polar axis. The magnetic charge produced to sensitive eyes in the dark, in miniature, at the representative poles, the luminosity and diversified colouring and play of light of the aurora (564-575). The needle is disturbed by the aurora, and will always, when suspended, direct itself to that point on the horizon to which the luminous streamers of the aurora converge, the summit of the arch lying directly above this point. "From all this," says General Sabine, "it appears, incontestably, that there is an intimate connection between the causes of auroras, and those of terrestrial magnetism" (Proctor, *Light Science for Leisure Hours*, 5).

The rotatory movement in his miniature globe, it would seem, was neither thought of nor obtained by Baron Reichenbach in his experiment, but a correspondent has communicated to me an illustration of its occurrence, the idea of which he derived from Farraday. "One of Farraday's experiments," he tells me, "I have myself made in model. A round ball of wood floats in water, with an iron wire through its poles. This wire has been made magnetic in the ordinary way, so that it has a north and south pole. The ball and its poles now represent the earth floating in space. By means of an electro-magnet at some little distance from it, the ball can be made to rotate on its axis." Some substances, Professor Tyndall informs us, when suspended between the poles of a magnet, are repulsed and set equatorially, or at right angles to the line of the poles. This is what is termed *diamagnetism.*

Others are attracted, and are set axially, or in the line of the poles (*On Diamagnetism*, &c., xi., xii.). In this manner the induced course of magnetic currents will set a body in rotation, a repulsive force driving the object in one direction, and an attractive force directing it the opposite way (*Ibid.* 98, 99). Baron Reichenbach, at page 23 of his work, has drawings of the visible flames of steel magnets being completely turned aside by the visible flames of electro-magnets; illustrating thus the power of magnetism to excite motion.

The magnetic influence exerted upon the earth has its representative poles and equator. The equator is that line where a suspended needle remains in equilibrium horizontally. This runs east and west, but does not coincide with the earth's equator, which it crosses at an angle of twelve degrees (Proctor, *Light Science*, 29). The magnetic poles are those points north and south, towards which the suspended needle dips the more and more it approaches them, its position becoming perpendicular at the poles. These poles do not coincide with the axis of the earth. Sir J. G. Ross found a magnetic north pole at 70° N. lat. and 263° E. long., and a south pole, which he approached, but could not actually reach because of ice, the position of which he has laid down at 75° S. lat., and 154° E. longitude (*Ibid.* 29, 30). In 1683 Halley enunciated a theory of there being four magnetic poles (Humbolt's *Cosmos*, II. 719), and Mr Proctor endorses the fact, mentioning that while there is a north magnetic pole in the direction of Lake Superior, westward of the meridian of Greenwich, there is another eastward in Siberia (*Light Science*, 32). The circumstance is of importance in judging the question of the earth's rotation by the means of solar magnetism. In the experiment by Baron Reichenbach, his globe, apparently, did not rotate, which may be accounted for by the line of magnetism being confined to the narrow limits and direction of the wire representing its axis. In the experiment by my correspondent, the magnet was held at some distance from his globe, and the magnetic discharge, ejected upon the surface of the globe, and commanding thus a certain breadth in space, had a leverage on the globe by which it effected its rotation. The earth is similarly acted upon by a broad belt of magnetism occupying the space between its two

sets of magnetic poles, and embracing, say 90° on each side of its axis of rotation, whereby the requisite leverage to produce rotation is obtained. The magnetism of the sun, it may be concluded, strikes the earth over its globular superficies in this broad band, disappearing where the rotund form of the earth recedes from arresting it.

The sun has a superficies which is 12,611 times that of the earth (Guillemin, 24). Our comparatively small globe, poised in free air, would be readily set in motion by its vast magnetizer. Its rotation is effected in something under twenty-four hours, while that of the moon, notwithstanding its very inferior bulk, occupies more than twenty-seven days. This, however, is consistent with the laws of magnetism, if we conceive the earth to be an induced magnet, receiving its influence from the sun, and the moon to be in like manner dependent for its magnetism and rotation on its governing orb, the earth. The earth having only a borrowed power to exercise towards its satellite, is comparatively with the sun a very much weaker agent, and its action on the moon is consequently feeble, and the rotation of the moon by so much slower. That Jupiter and Saturn, which are very much larger bodies than the earth, and more distant from the general magnetizer, the sun, should rotate much more speedily than the earth, namely, in about ten hours, is explained by their very much lower density.

The sun itself has a revolution on its axis, which is effected once in every twenty-five days. It is also moving through space, with its dependent orbs, apparently round some very distant centre. The sun, and all other associated systems, have, consequently, it may be judged, a supreme central governor, controlling their movements, as each minor system is controlled by its central orb. One system, moreover, will act upon and induce perturbations on another, as the units of each system act upon and disturb each other's movements. The sun, therefore, like the earth or any other of its dependent orbs, is apparently subject to direction and alteration in its course and movements by powers external to itself. We may, hence, readily understand that the sun may undergo changes of position which would alter its axis, and by consequence change towards the earth the direction of

that magnetic current emanating from it, which effects the axial rotation of the earth. In this manner the axis of the earth may be undergoing a slow constant movement relatively to the surface of the earth, bringing all places upon the surface under those climatic changes which it is plain they have experienced. The declination of the needle is continually varying. In 1492 it was in Europe towards the east. In about 1657 it pointed due north. After this its course was to the west; and in 1817 it was observed to retrograde to the east (Proctor, *Light Science,* 31). The magnetic equator is observably changing its position. In 1671 the inclination, or dip, of the needle was 75°; in 1791 it was less than 71°; and in 1831 it was less than 68°. In London the inclination in 1786 was 72°; in 1804 it was 70°; and at present it is 68° (*Ibid.* 30). These are circumstances which indicate variations of the solar magnetic current, assisting us to understand the possibility of that great movement which may be altering the position of the earth's axis, and affecting the climature of all places on its surface.

Such a revolution of the polar axis of the earth would subject every portion of the earth to four transitions of climate, in the extreme, in the course of one such rotation. Each part would be twice in a line with the poles, north and south, and twice, intermediately, in a line with the equator. It would be subject, in each rotation, to two glacial and two torrid epochs, these epochs alternating with each other.

The changes which have been noted in the upper series of the earth's strata are the following,—

1. Quaternary—Tropical and passing on to be Glacial.
2. Lower Quaternary—Glacial.
3. Pliocene—Tropical.
4. Upper Miocene—Glacial.
5. Miocene—Tropical.
6. Miocene—Glacial. (Not observed, but necessary to complete the series).
7. Lower Miocene—Tropical.
8. Eocene—Glacial.
9. Eocene—Tropical.

Thus in the Tertiary strata, of eight noticeable alternations

four belong to the Miocene period, which in geological charts is comparatively to the others a very narrow section. The probability, therefore, is that there have in this division of the earth's crust been several more climatic changes than have as yet been detected.

It is a received axiom that a sphere must rotate on its shortest axis. The earth does so, its axis of rotation being 139,670 feet, or a little above 26½ miles less than its diameter at the equator. This would be a difference, proportionately, of a tenth of an inch in a sphere measuring a yard in diameter (Guillemin, 98). If, then, the polar axis is altering its position, the sphere of the earth would have to counteract the movement by ever presenting for rotation its shortest axis, or the earth must change its form to adapt itself to its altering condition. In the former case we have to suppose a power in the earth to resist the effect produced upon it by its governing orb, and to direct itself in a line counter to the governor's movement. Moreover, the climatic changes we are seeking to account for would not occur while the earth's surface and its poles continued relatively in unaltered positions. We are driven, therefore, to the other alternative that the earth changes its form to adapt itself to its shifting poles, in consistency with which action there are certain corresponding indications.

The bulge of the earth at its equator is considered to be the effect of the greater degree of centrifugal force to which its crust is exposed in that quarter by its rotatory movement. The equator would shift in unison with the movement of the poles, and as each portion of the earth became equatorial, it would be subject to the higher centrifugal force there maintained; and yielding to the pressure, would, in keeping with the pace of the slow movement of the poles, gradually distend itself to the superior equatorial proportions, ever leaving, therefore, for the process of rotation, its shorter axis. It is just in that equatorial position that those disturbing forces chiefly prevail which are seen altering the earth's levels, producing elevations and depressions of its surfaces, and the equatorial line itself bears evidence of being disarranged by some such operating power. "The most recent results arrived at by geologists have taught us that the earth is not quite truly

represented by an orange, at all events, unless the orange be slightly squeezed, *for the equatorial circumference is not a perfect circle, but an ellipse,* the larger and shorter equatorial diameters being respectively 41,852,864 and 41,843,896 feet. That is to say, the equatorial diameter which pierces the earth from longitude 14° 23′ east to 193° 23′ east of Greenwich, is two miles longer than that at right angles to it" (Guillemin, 98); and other such irregularities may be supposed to exist elsewhere through a sphere subject to constant distention and compression.

Taking the crust of the earth in stratified and unstratified rocks to amount to twenty miles, the globe would be represented by a sphere with a diameter of thirty-three feet, and a crust of one inch in thickness. Such a crust having a measure of elasticity, it is easy to understand that its form, or diametrical dimensions, might be varied, within moderate limits, by the application of adequate force. That it has met with and yielded to such force, the condition of its strata makes manifest. These have for the most part been deposited horizontally as aqueous sediments, and afterwards have been upheaved and depressed at all angles. The "faults" in metallic loads are evidence of the operation of such force. The veins of the ore are found ruptured and displaced, it being one of the difficulties of mining to recover them. The dislocations in coal measures are of the like character. In a representative sphere of the dimensions I have suggested, a projection or depression of the supposed crust to the extent of a quarter of an inch would suffice to raise up or submerge our highest mountains; and an alteration of its diameter by less than an inch and a third, would establish the variation of diameter we now possess on comparing the polar with the equatorial axis.

Volcanic agency is also in greatest activity at the equator. The inhabitants of Peru, for example, live in constant terror of the disturbances to which the crust of the earth in that portion of the globe is subject. Mr Mayall's theory is that in the equatorial region, where the centrifugal force is greatest, and the crust of the earth most distended, volcanoes find their readiest vents, and then, through the pericycloidal movement which the earth, he conceives, is undergoing, pass to

the very various positions in which we find them. He has traced twenty-two nearly parallel lines circuiting the earth, along which volcanoes are ranged, which represent to him so many alterations of the equatorial circle. Thus, at other times, Hecla in the extreme north, and Mount Erebus in the extreme south, have been in the position of Chimborazo at the equator, and as the poles of the earth have altered their direction, and made parts which were equatorial polar, these arctic and antarctic volcanoes have been transferred to the places they now occupy relatively to the axis of rotation.

The phenomena of Kent's Cavern become readily explicable under the operations I have been describing, as consequent upon the movement of the poles of the earth. The cavern is subjected to some force which at various times has broken down large masses of its limestone lining, blocks of which are seen passing through all its deposits, and lying upon the mould which forms its surface floor. Fragments of this limestone pervade all the deposits, and probably constitute in chief part the solid breccia which is its fifth deposit. Those who are engaged in exploring the cavern have naturally apprehended that the roof over them may be in an unsound condition, but, on testing this, it has been found perfectly safe. The committee, in dealing with the subject, thus express themselves,—"Since the large masses of limestone occur at all levels in the cave earth, as well as everywhere above it, it is obvious that, whatever may be the cause to which their fall is attributable, they cannot be referred to any one and the same period. They fell from time to time throughout the accumulation of the cave earth; they continued to fall whilst the stalagmite breccia was in process of formation, as well as during the introduction of the black mould ; and they are amongst the most recent phenomena which the cavern presents. . . . It is by no means easy to determine the cause which threw them down. To call in the aid of convulsion seems undesirable, since it would be necessary to do so very frequently. Moreover, it may be doubted whether anything short of a violent earthquake would be equal to the effect. Though the roof of the chamber is of very great span and entirely unsupported, and though it presents appearances which are not calculated to inspire con-

fidence, the violent concussions produced by the frequent blastings already mentioned, blastings which not unfrequently threw masses of limestone, weighing upwards of a ton, to a distance of several feet, have never brought down even a splinter" (*Report for* 1865, iv.). There has also been the disruption of the lower stalagmite and breccia floorings. The three superior deposits, namely, the black mould, the uppermost stalagmite floor, and the red cave earth, remain *in situ* undisturbed, but the dense deposits forming the second floor of stalagmite, the brown breccia below it, and the lowest observed floor of stalagmite beneath that, have undergone great violence, by which they have been more or less broken up. The Committee frequently notice these disruptions, and thus treat more particularly of the condition of the second stalagmite floor. "As has been stated in previous reports, the Committee have long been familiar with the presence of blocks of stalagmite in the cave earth, and have inferred from them that an ancient floor of the cavern had been broken up by natural agency before or during the introduction of the cave earth. There seemed no difficulty in conceiving of a machinery by which such a floor might have been destroyed in the comparatively lofty chambers. For example, it was known that the deposit which the old floor had covered, and on which it had been formed, had been, in some parts of the cavern, partially dislodged, or had subsided so as to leave the floor unsupported; it was also known that blocks of limestone, some of them scores of tons in weight, had from time to time fallen from the roof, and it was not difficult to see that such blocks would break into fragments any such unsupported floor on which they might fall. This, however, utterly fails to account for the destruction of the floor which once existed in at least some of the narrow passages of the North Sally-port. That such floors have been destroyed admits of no question, since, as has been already stated, remnants of them still adhere to the walls, to say nothing of their abundant fragments in the deposit below. That they were not destroyed by the fall of blocks of limestone is obvious from the facts that their remnants on the walls show that they were almost in contact with the roof even as it now exists, and that the roof itself presents no

indications that such masses have been detached from them. This problem still awaits solution" (*Report for* 1870, p. 28).

The magnitude of the force which has caused the disruption of the limestone of the cavern, and the breaking up of its floors, is apparent. It is equally apparent that it is a recurrent force, not always in operation. The limestone has been broken down at various times; and the cavern being found at present in a sound condition, no such process, it is evident, is now going on. In like manner the floor deposits have been acted upon at different times, and are not now being disturbed. The two lower floors of stalagmite, with the intervening breccia, have been subjected to the force in question; but the cave earth, upper stalagmite floor, and superficial mould, continue intact, and have, therefore, not been so circumstanced as to suffer from it. The altering condition of the earth, caused by the continuous alteration of its poles, explains the whole matter. The cavern, when in an equatorial position, has been subjected to the distension and compression there occurring. The Committee contemplate something with the power of an earthquake as necessary to have produced the effects before them, and the cavern, when thus situated, would be just so visited. The older floors have been in circumstances to experience the struggle of the earth to attain its equatorial dimensions, and have been injured accordingly. The rock, and the firmly compressed breccia, were of unyielding texture, and had to give way in fraction. The lower stalagmite floors having become crystallized were equally unyielding, and suffered proportionately. The cave earth is of looser consistency, and accommodated itself to the pressure put upon it, as did the upper floor of stalagmite, which is for the most part granular. Their time of disruption has yet to come.

The occurrence of several distinct floors of stalagmite, of which three are discernible in Kent's Cave, and two in other caverns in England, France, and Belgium, is due to some general cause which has interrupted the drip, and then allowed it to flow again. The passage of the caverns into a glacial temperature, which would freeze and bind up the drip, and their transference subsequently to a warm temperature which would thaw and set it free, will account satisfactorily for these recurring floors. The alternations in the caverns are therefore

evidence of the climatic changes to which the earth, through the movement of its polès, is subjected.

I will endeavour, on this footing, to trace the history of the several deposits in Kent's Cavern. The third or lowest floor of stalagmite, I will presume, was formed when the cave was passing through a temperate and equatorial climate, from say latitude 70° South to 70° North. At this time disruption of limestone from the inner lining of the cavern would have taken place, caused by the distension of the earth's surface when this part was at the equator. The materials of the breccia flooring would then be deposed, the stalagmite filtering through it and forming itself below. At the same time the human and animal remains were deposited in the then loose breccia. For the period marked by a change of 40 degrees, measuring 20° on each side of the North Pole, a glacial temperature prevailed. The drip was frozen up, and the earthy ingredients mixed in with the breccia were gradually added to it. The cavern was then again subjected to warmth from latitude 70° north to 70° south, and the drip being resumed, the second floor of stalagmite was produced. Then also occurred the equatorial disruptions, and the stratum of cave earth was formed ; and the new deposits became stocked with animal and human remains of the period. These remains abound in the lower levels of the cave earth, which belong to the non-glacial period, and are more rare in the upper levels, which I assume to have been completed during the next occurring glacial period. At this, or at the next occurring equatorial period, the lowest floor of stalagmite may have been broken up. The cavern then passed through the glacial epoch ensuing, in its passage over forty degrees, or twenty on each side of the South Pole, when the drip was interrupted and the stratum of cave earth completed. The cavern once more passed into a warm climate from 70° south to its present position at say 50° north latitude. The drip was resumed, and the formation of the upper floor of stalagmite, now in process of completion, was entered upon; the equatorial disruptions occurred, breaking up the two older stalagmite floors and the breccia, and bringing down fresh blocks of limestone; the black mould was at the same time introduced, the stalagmite dripping through it as on the former occasions, and the human and animal remains of this

period were furthermore deposited. When the cavern is subjected to a further change to bring it to lat. 70° N., the next glacial epoch may be expected. The deposits of the cavern thus represent one entire revolution of the poles of the earth, and a further passage over 120 degrees, during which the existing modern floors have been forming.

The movement of the polar axis of the earth involves a corresponding change of its equatorial line, and this circumstance suffices, I apprehend, to account for the ever varying alteration of the angle formed by the equator with the ecliptic. The rate at which the angle changes, if understood, would give the rate at which the revolution of the poles is effected. The astronomical manuals describe the rate as if an invariable one of 48″ in a century. Col. Drayson states it as at present 45″ in that period, and maintains that it is a rate continually altering. At page 122 of his work he supplies a table of eleven observations of the condition of the angle made from A.D. 1437 to 1870, which, by the comparison of one period with another, give a mean variation of nearly 59″ in a century. For the sake of approximate calculation I may be allowed to take 60″, or one minute, in a century, as the rate at which the angle changes, and by consequence at which the poles of the earth undergo their rotation.

The stalagmite flooring of Kent's cave is formed in very thin laminæ, laid down with exceeding slowness. In 1846 a portion of the upper floor, to an extent of about six feet in diameter, was removed, and the cave earth below was dug up and examined. "Probably," say the Committee, "no part of the cavern is in wet weather more exposed to drip than this; hence it might have been expected that here, if any where, twenty-two years would have produced a film of stalagmite of appreciable thickness, especially as it was known that the modern floor attains an average thickness considerably surpassing that in any other part of the cavern which the Committee have explored. Yet not a film was to be found either at the bottom of the pit, on the section made in digging it, or on the cave-earth thrown out of it" (Report of 1868, p. 50). There are two parts of the cavern where inscriptions of names and initials of visitors, with the dates, have been made on surfaces of the upper stalagmite. In one place, called *The*

Cave of Inscriptions, the oldest date is of 1688, and in another, called *The Crypt of Dates*, they reach to 1618. "In looking at those dates," observe the Committee, "it seems impossible to abstain from reflecting on the facts that they are cut on the upper surface of a mass of stalagmite upwards of twelve feet thick, in a locality where the drip is unusually copious; and that two and a-half centuries have failed to precipitate an amount of calcareous matter sufficient to obliterate incisions which at first were probably not more than an eighth of an inch in depth" (Report of 1869, p. 196). The over twelve feet of stalagmite here spoken of, it is to be remarked, is formed by the upper and the second floor of stalagmite at this place meeting together. The second, or completed floor, according to the views I am setting forth, was composed while the cavern was undergoing a change of position relative to the poles embracing 140 degrees, and the upper floor has been forming during a transference over 120 degrees. According to this scale, eighty inches may be allowed for the thickness of the second floor, and seventy for that of the upper one. Mr Vivian, in a paper on the evidences of Glacial Action in South Devon, laid before the Devonshire Association for the Advancement of Science in the year 1868, speaking of the inscription of 1688 in the *Cave of Inscriptions*, assumes that the rate of deposit thereupon may have been "one-tenth of an inch" "during each one thousand years." This would give a rate of a fortieth of an inch in the two and a-half centuries marked in the oldest inscriptions in the *Crypt of Dates*. A deposition at that rate would have occupied no less than 700,000 years to have formed the 70 inches of stalagmite which I have assumed to be the thickness of the upper floor of stalagmite at the place of these inscriptions. The astronomical period for the progress of the poles of the earth over the said 120 degrees during which this floor was, as I conceive, forming, at the rate I have assumed of one minute in a century, would be 720,000 years, which tallies remarkably with the period estimated by the supposed rate of deposition of the drip. At the lower part of this upper floor, it will be remembered, has been found part of a human jaw-bone, and the flint flakes and implements pervade the deposit. The succeeding lower deposits of the cave-

earth and second floor of stalagmite represent the preceding period of warm temperature for the cavern. This involves a passage of the poles over 120 + 40 + 140 degrees, or 300 degrees, for which, at the rate of change of the angle of the ecliptic, 1,800,000 years is required. In this era, besides the celts, we have the evidence of the charred deposit, termed the Black Band, and the bone implements found therein and below it. During the formation of the breccia, and the lowest floor of stalagmite, the poles were passing over 40+140 degrees further back, making a total of 480 degrees, for which 2,880,000 years are requisite. This represents the total estimated age of the deposits of the cavern, and in this era, in the breccia, flint implements have been obtained, while in a parallel deposit in the Trou de la Naulette, is the more decisive evidence of a human jaw-bone, a human arm-bone, and a fragment of reindeer, apparently perforated by a human artist. It would seem, therefore, from the testimony before us, that we must accord to man existence upon the earth for something like three millions of years.

The age of the earth cannot be thus closely traced as the alternations of climate marked upon its surface do not in all parts readily disclose themselves. The cretaceous and coal systems afford the best available testimony on this head. In the upper chalk beds are found two hundred layers of flints alternating with the chalk. Mr Bowerbank and others are of opinion that flints have been formed from sponges. Ehrenberg has observed among them abundant traces of infusorial animalculæ (*Nat. Encycl.*). Occurring only in the chalk, they must be taken to be sub-marine animal formations. Col. Drayson suggests that these alternations may be due to the climatic changes the earth has undergone. Possibly the ordinary cretaceous animalculæ may mark the seasons of warmth, and the silicified sponges those of cold. The flints, with an equal number of chalk deposits, would thus represent four hundred such alternations. With the one hundred and twenty seams of coal at Saurbrücher, besides a great many more of less than a foot in thickness, and the one hundred and forty-seven seams of the Cumberland series, we may be warranted in supposing that there have been one hundred and fifty such seams, if all were known of, which, with the intervening beds

of shale and clay-slate, gives in this field three hundred alternations. Seven hundred alternations of climate represent one hundred and seventy-five revolutions of the poles, which, at 2,160,000 years for each revolution, amounts to a period of three hundred and seventy-eight millions of years; and this embraces only portions of the earth's crust, probably amounting to not more than a sixth of its entirety.

It will of course be objected to my suggested movement that the geographical changes it involves have not yet been observed to occur. The value of this objection depends upon whether the condition of scientific knowledge is such that we may conclude what astronomers have not detected does not exist. It is not three hundred years since Galileo was denounced by every astronomer in Europe for his assertion that the earth revolved daily upon its axis; a very precise nutation of the poles, attributable to the influence of the moon when the earth executes the precessional movement, was first noticed two hundred and twenty-six years ago by Bradley; it is less than one hundred years ago, or in 1781, that Herschel discovered the important planet Uranus; it is only twenty-eight years ago since the still more important planet Neptune, was brought to our knowledge by Adams. At the beginning of the current century but seven minor planets were known of circulating between Mars and Jupiter; their number is now found to be close upon a hundred, and is continually being added to; and in the early part of this century navigators had to content themselves if, with their imperfect quadrants, they came within thirty or even fifty miles of their true positions. Two movements of the poles of the earth have come under observation,—one their slow gyration occupying nearly twenty-six thousand years, which effects the changes of the equinoxes, the other a system of short frequent nutations, measuring about 10″ of the arc, occurring in this precessional gyration; but at the same time the true course of the poles in this movement, whether circular, elliptical, or possibly spiral, has not yet been ascertained. Under all these circumstances that another very slow movement of the poles, belonging to a cycle apparently of over two millions of years, proceeding only at the rate of less than half a second of the arc in a year, and perhaps complicated with the other known movements of the poles,

should not have been detected, is assuredly no sufficient cause for disallowing the possibility of its occurrence.

The actualities of our astronomical system have occasionally been brought to light through their observed effects. The fall of an apple exposed the law of gravitation, and the perturbations of Uranus led to the discovery of Neptune. The great climatic changes to which the earth has been subjected have only attracted serious attention of late years. They are of a character naturally to have been forced upon the view before the operation effecting them might be discerned. Various have been the efforts to account for these phenomena through known circumstances, but it is allowed that as yet they baffle explanation. Equally have other phenomena, such as the gradual alteration of the earth's levels, the distortion and dislocation of stratified deposits, the disruption of rocky caverns, and the recurrence of successive deposits of stalagmite in such localities as Kent's Cave, defied solution. And where Leverrier goes so far beyond the point at which La Place's calculations require that the supposed alteration in the plane of the ecliptic should cease and be followed by a retrograde movement, the phenomenon of the change in the angle of the ecliptic has to be added to the number of the unsolved problems. The movement I have suggested has the merit of embracing the whole range of these difficulties, and will account for them all. It does so with a simplicity and a certainty consonant to all the grander operations in nature, and in conformity with principles effecting similar and less consequential changes. One astronomical movement brings us night and day, another alters the seasons, and it is reasonable to suppose that it is due to a third such movement that the climature of the earth undergoes its evidenced transitions. "There is no more convincing proof," observes Mr Wallace, "of the truth of a comprehensive theory than its power of absorbing new facts, and its capability of interpreting phenomena which had been previously looked upon as unaccountable anomalies" (Bastian, *The Beginnings of Life*, II., 605, 606). Mr Herbert Spencer has a similar sentiment *Prin. of Bio.*, I., 291), and it is one that will assuredly commend itself to all.

The sun being the great supporter and regenerator of the

terrestrial system, it is a fitness of arrangement which may present every portion of the globe to receive in turn his genial influences. According to existing apprehension, such is not the case. Each region of the globe, it is currently held, within circumscribed limits, preserves ever its own portion of his regards. The polar countries have but a scant measure of his influences, while the tropics may be said to be overcharged with his continual presence. One place is habitually buried out of sight in ice, and another scorched up in unbearable drought. The movement I contemplate introduces equal treatment, in time, for all parts of the earth, which become in turn arctic, temperate, or tropical. The capabilities of the earth, in every direction, are put to use, or laid by in disuse, and its productions in every field of organized life are cherished, regulated, expelled, or put an end to, and resuscitated, in an endless variation of its circumstances. The development of the composite materials, and therewith of the capabilities of the globe, progresses with continually increasing advantages. Order and race succeed one another. The older systems and species, after serving their ends, are set aside in favour of higher advances in the limitless progress of the great deviser, sustainer, and director of all things, for the manifestation of what he may purpose in the exhibition of his goodness and power; so that the more we see of his works the deeper is our admiration of them. To the present enlightened generation it is given to observe and apprehend these high results, in a measure hitherto unattained. The heavenly orbs are opened out to them, group beyond group, through an interminable expanse. Their own system especially invites their study in its exquisitely balanced arrangements. And the globe they inhabit presents a well arranged calendar, now beginning to be understood, recording those long sustained operations which have been directed towards it for their good. To know the works of the Almighty as they should be known, is to get in them a glimpse of himself.

POSTSCRIPT.

Since the foregoing pages were prepared for the press, Professor Geikie's work, entitled "The Great Ice Age," has, in the current year, made its appearance. I have thought it preferable to deal with this important publication separately, rather than serve myself of its contents by introducing them into the body of my work.

Professor Geikie comes to his task as a practical and experienced geologist, and it has been a satisfaction to me to find his facts entirely in keeping with those upon which I have worked out the theory I have ventured to advance in explanation of the observed phenomena. I must be excused, therefore, for making liberal use of the materials thus placed within my reach.

Professor Geikie describes that glacial deposit found in Scotland, which has been the special field of his observations, known under the name of Till. This consists of stiff clay, containing numerous pieces of stone or rock, which are water-worn and striated, or marked by lines running mostly in parallel directions, scratched or furrowed into them (10-15). This deposit is universally recognized as the result of glaciers, which, being in constant motion, grind down the clay and score the loose harder pieces of material met with in their path against the solid rocky surfaces below, over which they are making their passage. The till, consequently, is ground moraine (86-88). It runs in places to a thickness of 100 feet and upwards (16), and has been seen at heights of 2300 feet (94). Scratchings of the stones thus carried forward, and which may be called ice-chisels, are found over the valleys and on hill-tops in the Highlands, to elevations reaching to as much as 3500 feet (83).

This is evidence derived from the bottoms, or the foundations of the moving glaciers. Corresponding evidence is obtained by operations at their upper surfaces. We have presented to us thick coatings of ice, with the tops of the mountains alone uncovered and projecting above the ice. The agency of severe frost is continually splitting and breaking off fragments of these mountain tops, and depositing them upon the glaciers (49, 53); and as the glaciers move forward, they

are borne along, and are finally deposited upon the earth, wherever high lands may arrest the progress of the ice, or where the glaciers may finally disappear by melting under the recurring change to a warm climature. The fragments so transferred are what are known as erratic boulders. These are met with upon hill tops to which they could not possibly be transferred but by the ice agency which suggests itself. "Water might roll them down from one hill into a valley, but it could hardly push them up another hill, and so repeat the process often in a distance of many miles" (30). The size of these erratics, as well as their position, forbids the idea that any amount of water power could have effected the transferences they have undergone. "The mountains that hem in Loch Doon (Ayrshire) are sprinkled with loose angular and subangular stones, some of them striated, and with immense numbers of large boulders of grey granite which do not belong to the hills upon which they rest, but have travelled outwards from the central mountain region." They "are scattered promiscuously over all the hill-tops up to a height of 1700 feet." They "appear near the very top of Beneraird (1400 feet above the sea)." In the Highlands, "the mountain-slopes are everywhere sprinkled with loose earthy rubbish, in which a few faintly glaciated stones sometimes occur, and large erratics occur up to all levels, even as high as 3000 feet, according to Mr Jamieson" (219, 220). "Erratics are of all shapes and sizes—occasionally reaching colossal proportions, and containing many hundred cubic feet. Some are rounded, others only partially so, and very many are angular and sub-angular; not a few also show one or more scratched surfaces" (221). "They are met with here and there in the low-lying parts of Fife, and Mr Maclaren has described the occurrence of a large mass of mica-slate at a height of 1020 feet on the Pentland Hills—the nearest rock from which it could have come lying fifty miles to the north or eighty miles to the west. Boulders of Highland rocks have also been noted on the northern slopes of the Lammermuir Hills. They likewise occur in considerable numbers on the crests of the trappean heights that rise between the valleys of the Clyde and the Irvine" (222). "What, then, do we learn from the erratics? How do we account for the

scattering of these far-travelled blocks over, we may say, the whole face of the country? Some of them, it is evident, must have crossed wide valleys and considerable hills before they came to a final rest. The Highland boulders on the Pentlands and the Lammermuirs, for example, after crossing Strathallan or Strathearn, traversed either the Campsie or the Ochil Hills, and passed athwart the broad vale of the Forth before they finished their journey. By what agent were they transported? The answer is—by a colossal glacier. So, in like manner, would I account for the presence of the numerous grey granite boulders that strew the slopes of the Galloway mountains, and are found distributed far and wide over the low grounds at their base; for the boulders that cluster so numerously along the northern face of the Ochils; for the perched blocks that occur up to great heights in the glens and valleys of the Highlands; and for those that dot the surface of Orkney and Shetland, and the islands of the Hebrides" (223, 224).

By these concurrent testimonies furnished by the ground moraines below the glacial formations, the scratchings made by the ice in its passage over the up-lands, and the erratic boulders which have travelled on the surfaces of the glaciers, all leaving their traces over long distances and at considerable elevations, it has become apparent that Scotland, at one time, has been buried under a mass of ice which must have been more than 3000 feet in thickness, a few hill-tops alone appearing above this *mer de glace* (83, 86, 95, 98, 225). Other countries have been similarly visited. The ice-sheet has spread across the valleys of Great Britain (504). The present glaciers of Switzerland are pigmies compared to those of ancient times, whose traces are apparent (84). "The Jura Mountains, as every one knows, extend in a long series of parallel ridges from south-west to north-east, between the valleys of the Rhone and the Rhine. From the base of these mountains the low grounds of Switzerland roll themselves out to east and south-east, until they sweep up against the great barrier of the Alps. Now upon the southern flanks of the Jura we find numerous scattered blocks and boulders, all of which have been carried from the Alps across the intervening plains, and left where we now see them. Some of the blocks

are of enormous dimensions; many contain thousands of cubic feet, and not a few are quite as big as cottages. Indeed, one of them, the great granite boulder of Steinhoff, might be compared, as Mr Maclaren has remarked, to 'a goodly-sized house of three storeys.' Such blocks have been observed on the Jura at a height of no less than 2015 feet above the surface of Neufchatel, or 3450 feet above the sea; and from this elevation, downwards, they are strewn in greater or smaller numbers along the whole mountain-slope that faces the Alps. Towards the north-east, where the Jura begins to lose in height as it approaches the valley of the Rhine, we find the erratics scattered not only along the southern slopes, but even over the tops of the mountains. According to Swiss geologists, these erratic blocks and boulders have been carried down from the Alps on the surface of a mighty *mer de glace*, underneath which the whole of the central low grounds were at one time buried. This vast sheet of ice, not less than 3000 feet in thickness, stretched continuously outwards from the Rhone Valley, and abutted upon the Jura, the higher ridges of which rose above its level" (399, 400). The ancient Rhone glacier advanced across the plains of Switzerland, abutted upon the Jura, joined the glacier of the Rhine, and spread over a distance of 270 miles before it reached its end (400-402). Norway has been under the pressure of ice "which could hardly have been less than 6000 or 7000 feet thick" (381). The whole continent of North America, from the Arctic Ocean to New York, has been under ice (411), and "the thickness attained in Connecticut by the continental ice-mass, has been estimated by Dana to have reached 6000 feet or 8000 feet" (419, 420).

The conclusions thus arrived at from the traces of glacial action observed, are borne out by the actualities to be seen in countries at present subject to the degree of cold that can produce such coatings of ice. These, of course, lie in the neighbourhood of the poles. "Glaciers, like rivers, are of all sizes. Many have a depth of several hundred feet, and some in polar regions are probably not less than 3000 or even 5000 feet in thickness" (49). "The superficial area of Greenland cannot be less than 750,000 square miles, so that the country is almost continental in its dimensions. Of this

great region, only a little strip extending to 74° north lat., along the western shore, is sparsely colonized—all the rest is a bleak wilderness of snow, and ice, and rock. . . . The whole interior of the country, indeed, would appear to be buried underneath a great depth of snow and ice, which levels up the valleys and sweeps over the hills. The few daring men who have tried to penetrate a little way inland from the coast, describe the scene as desolate in the extreme—far as eye can reach nothing save one dead dreary expanse of white. No living creature frequents this wilderness—neither bird, nor beast, nor insect—not even a solitary moss or lichen can be seen. Over everything broods a silence deep as death, broken only when the roaring storm arises to sweep before it the 'pitiless blinding snow" (55, 56). "Glaciers, as we have seen, enter the sea at many places along the Arctic coasts—often filling up those long deep sea-valleys or fiords which in lower latitudes form commodious natural harbours, and frequently penetrate for many miles into the interior of a country. Of such a character are the friths and fiords of Scotland and Norway. . . . The deep fiord valleys still continue, but they are choked up with glaciers, which have pushed out the sea and occupied its place. As these glaciers slowly creep on to profounder depths, a point is reached at which, as already described, the pressure of the dense sea water becomes too strong for the tenacity of the glacier to resist; and thereupon the ice ruptures, and great masses surge upwards and float off as icebergs. Some of these bergs attain a prodigious size. Dr Hayes measured one which had stranded off the harbour of Tessuissak to the north of Melville Bay, and estimated it to contain about 27,000,000,000 of cubical feet. This berg could not have weighed less that 2,000,000,000 of tons; it was aground in water nearly half-a-mile in depth. What, then, must have been the thickness of the glacier from which it had been detached? Captain Ross, in his first voyage, describes another iceberg of gigantic proportions. This mass of congelation had stranded in sixty-one fathoms of water, and its weight was estimated at 1,292,397,063 tons" (70, 71). "Sir J. C. Ross's striking account of the mighty ice-sheet under which the Antarctic continent lies buried, gives one a very good notion of the kind of appearance which the skirts

of our own ice-sheet presented. After reaching the highest southern latitude which has yet been attained, all his attempts to penetrate further were frustrated by a precipitous wall of ice that rose out of the water to a height of 180 feet in places, and effectually barred all progress towards the pole. For 450 miles he sailed in front of this cliff, and found it unbroken by a single inlet. While thus coasting along, his ships (the *Erebus* and *Terror*) were often in danger from stupendous icebergs and thick pack-ice, that frequently extended in masses too close and serried to be bored through. Only at one point did the ice-wall sink low enough to allow of its upper surface being seen from the mast-head. Ross approached this point, which was only some fifty feet above the level of the sea, and obtained a good view. He describes the upper surface of the ice as a smooth plain, shining like frosted silver, and stretching away as far as eye could reach into the illimitable distance. The ice-cliff described by Ross is the terminal front of a gigantic *mer de glace*, which, nurtured on the circum-polar continent, creeps outward over the floor of the sea until it reaches depths where the pressure of the water stops its farther advance by continually breaking off large segments and shreds from its terminal front, and floating these away as icebergs. And such must have been the aspect presented by the margin of the old ice-sheet, which, in the early stages of the glacial epoch, mantled Scotland and its numerous islets, filling up the intervening straits and channels of the sea, and terminating far out in the Atlantic Ocean in a flat-topped vertical cliff of blue ice" (101, 102).

Such has been, and is, the coating of ice prevailing over extensive portions of the earth at different times. And the condition has been a frequently recurring one. Deposits of glacial till have been found intercalated with stratified beds of sand and clay (158). There are such beds varying "in thickness up to twenty or thirty feet, and in them layers of peat and decaying twigs and branches have been detected. They were clearly overlaid and underlaid by tough stony till" (160). "The intercalated beds are remarkable from having yielded an imperfect skull of the great extinct ox (*Bos primigenius*); and remains of the Irish elk or deer, and the horse, together with layers of peaty matter" (162). In similar positions "the

remains of mammoths and reindeer and certain marine shells have several times been detected" (162). "It is reasonable to conclude that there were times when the great ice-fields that covered the country receded so far at least as to uncover the lowland tracts and valleys, and permit the accumulation in those regions of clay, sand, and gravel. Nor does it seem less reasonable also to conclude that after such a recession the ice again advanced and covered up the aqueous strata with thick deposits of stony clay" (166). "The borings prove the existence of two masses of till, with intervening and underlying beds of silt, mud, sand, and gravel (174). The presence of forty feet of silt, sand, and gravel above the till indicates a period of lessened cold, when the ice-sheet disappeared from this region, and permitted the formation of such deposits. But after a time it would appear that the ice-sheet again overspread the country, doubtless sweeping out the silt, sand, and gravel from exposed positions, but sparing them in the narrow glens and gullies that intersected its path" (175). The author gives a table of the strata disclosed at borings at the estuary of the Forth, which exhibits four several depositions of till with stones, divided from each other by intervening beds of sand (177, 178). Speaking of borings in the valley of the Kelvin, he says, "A glance at the 'borings' given above (pp. 183-4) will show that the buried hollows and ravines may contain more than one stony clay separated by considerable depths of aqueous deposits. These stony clays probably indicate just so many incursions of the ice-sheet; the intermediate beds of silt, sand, and gravel, may point on the other hand to periods when the ice vanished from the low-grounds and crept back to the mountain valleys" (190). "Both lower and upper masses of till shown in the section, are crammed with well striated stones and boulders, and are in all respects typical deposits" (194). "The presence of the intercalated river gravel and sand indicates plainly that an interruption to this arctic condition of things took place. Before these river deposits could be laid down, the ice must have vanished from the Leithen valley, and if such was the case with this mountain-valley, we are driven to conclude that the great ice-sheet could not then have covered any portion of the Scottish lowlands. Glaciers may have lingered still in the higher

valleys of the country, but it is obviously impossible that a great ice-sheet could exist while upland streams like the Leithen had freedom to flow. The aspect of the upper deposit of till in the section testifies to the disappearance of the mild conditions under which the river accumulations were formed, and to the return of an intensely arctic climate" (194, 195). "Combining the evidence we learn that not only did the great ice-sheet sometimes retire from the low grounds, and give place to lakes and streams and rivers, but also that, during such periods of milder conditions, a vegetation like that of cold temperate regions clothed the valleys with grasses and heaths, and the hill-sides with birch and pine. Rein-deer wandered across the country, while herds of the great white ox, the horse, the Irish deer, and the woolly-coated mammoth frequented the grassy vales" (196). "If the accumulation of the lower mass of till at Airdrie implies the former existence of one great confluent ice-sheet in Scotland; then, in like manner does the overlying mass of till compel us also to conclude that after a comparatively mild period had endured, for some time, another mighty ice-sheet again overflowed the land" (202). "We have found that there is abundant proof to show that the accumulation of a *moraine profonde* by one great ice-sheet, was interrupted several times; that the ice-sheet vanished from the low grounds, and even from many of the upland valleys, and that rivers and lakes then appeared where before all had been ice and snow. We have also learned that during such mild inter-glacial periods, oxen, deer, horses, mammoths, reindeer, and, no doubt, other animals besides these, occupied the land" (204). "A glance at the foregoing tables will show that the oldest glacial deposits (ground moraines), have yielded evidence of inter-glacial mild conditions in the following countries: viz., in Scotland, England, Scandinavia, and North America" (428; see also 429, 475). These evidences show that the great climatic changes they mark have been recurrent. And it is thought all the older deposits, reaching through the Tertiary, Secondary, and Primary systems, as low down as the Silurian beds, afford proofs of the like alternations (511).

In the times intervening between the visitations by ice, the climate, in the same regions so visited, has risen to be

temperate and tropical, as is evidenced by the imbedded remains of the products, vegetable and animal, which have occupied them. "The story, recorded everywhere, assures us that from the earliest times of which geologists can take cognizance down to the present, our globe has experienced many changes of climate. The plants of which our coal-seams are composed, speak to us of lands covered with luxuriant growths of tree-ferns and auracarians, and the fossils in our limestones tell us of warm seas where corals luxuriated in the genial waters. Nor is it only in our own latitudes that scenes like these are conjured up by a study of the rocks. Even in high arctic regions, where the lands are well-nigh entirely concealed beneath the snow, and where the seas are often choked with ice all the year round, we often meet with remarkable proofs of genial and even warm climates having formerly prevailed at several widely separated periods. Limestones containing fossil corals, and numerous remains of extinct chambered shells, such as are now represented by the nautilus of the Pacific Ocean, occur frequently in the highest latitudes yet reached by man. Dr Hayes brought from the bleak shores of Grinell Land certain fossils, the nature of which clearly indicates that at some distant date, a genial ocean, capable of nourishing corals and chambered shells, must have overspread that region. Similar results have been obtained by many of our most distinguished arctic voyagers, and from their observations it is now well ascertained that over all the regions within the Arctic circle which have yet been visited, genial climates have prevailed at different times during past geologic ages—climates that not only nourished corals and southern molluscs in the seas, but clothed the lands with a rich and luxuriant greenery" (103, 104). Professor Newberry has described the occurrence of a regular forest-bed, intercalated among true glacial deposits, and bones of the elephant, mastodon, and great extinct beaver, have been found in the same position" (417). Remains of the elephant and rhinoceros have been met with in Switzerland (429), and those of the hippopotamus have appeared at Leeds (491). The author arranges the different animal fossils according to the climates proper to them. The existence of the glutton, reindeer, musk-sheep, pouched marmot, alpine hare, lemming,

mammoth, woolly rhinoceros, bespeak an arctic climate; that of the bison, urus, grizzly bear, cave-bear, Irish elk, Brown's deer, lynx, wild cat, ermine, stoat, weasel, martin cat, otter, wild boar, horse, beaver, &c., one that was temperate; and that of the lion, tiger, spotted hyena, elephant, rhinoceros, hippopotamus, one that was tropical. "It is quite impossible," he observes, "that these animals could have lived side by side." The reindeer of Lapland and Norway, and the hippopotamus of Southern Africa, it is obvious, could not have inhabited the same region together (451, 452). "We must admit, in short, that the northern mammalia occupied Britain during a cold and arctic condition of things, and that on the other hand the southern forms prevailed over the same area at a time when our winters were mild and genial" (467).

The author thus portrays the transitions undergone. Taking the present northern temperate zone up at a time when it was under the domination of ice, he says, "Ere long, this wonderful scene of arctic sterility passed away. Gradually the snow and ice melted, and drew back to the mountains, and plants and animals appeared as the climate ameliorated. The mammoth and the woolly-coated rhinoceros roamed in our valleys, the great bear haunted our caves, and pine-trees grew in the South of England; but the seasons were still well marked. In winter-time, frost often covered the rivers with a thick coat of ice, which the summer again tore away, when the rivers, swollen with the tribute of such receding glaciers as still lingered in our deeper glens, rushed along the valleys and spread devastation far and wide. By slow degrees, however, the cold of winter abated, while the heat of summer increased. As the warmth of summer waxed, the arctic mammalia gradually disappeared from our valleys, and sought out northern and more congenial homes. Step by step the climate continued to grow milder, and the difference between the seasons to be less distinctly marked, until eventually something like perpetual summer reigned in Britain. Then it was that the hippopotamus wallowed in our rivers, and the elephant crashed through our forests; then, too, the lion, the tiger, and the hyena became denizens of the English caves. Such scenes as these continued for a long time; but again the

climate began to change. The summers grew less genial, the winters more severe. Gradually the southern mammalia disappeared, and were succeeded by arctic animals. Even these, however, as the temperature became too severe, migrated southward, until all life deserted Britain, and snow and ice were left in undisputed possession. Once more the confluent glaciers overflowed the land, and desolation and sterility were everywhere" (505, 506).

The traces of man, prominently afforded by the stone implements used by him, occur in conjunction with these animal remains. They have been found in positions showing man to have been on earth before the last glacial epoch (482). A remarkable evidence of this fact has recently been brought to light. "Mr Tiddeman writes to *Nature*, Nov. 6, 1873, that amongst a number of bones obtained during the exploration of the Victoria Cave, near Settle, Yorkshire, there is one which Mr Busk has identified as *human*. Mr Busk says: 'The bone is, I have no doubt, human; a portion of an unusually clumsy fibula, and in that respect, not unlike the same bone in the Mentone skeleton.' The interest of this discovery consists in the fact that the deposit from which the bone was obtained is overlaid, as Mr Tiddeman has shown, 'by a bed of stiff glacial clay, containing ice-scratched boulders.' Here, then, is direct proof that man lived in England *prior to the last inter-glacial period*" (510, note).

Another series of phenomena connected with the investigation before us is the condition of the stratified beds, and the alterations of the sea-levels. These have necessarily occupied Professor Geikie's attention. He states, "We find that the intercalated beds of sand and gravel give unequivocal proof of having been subjected to great pressure. They are twisted, bent, crumpled, and confused, often in the wildest manner. Layers of clay, sand, and gravel, which were probably deposited in a nearly horizontal plane, are puckered into folds, and sharply curved into vertical positions. I have seen whole beds of sand and clay which had all the appearance of having been pushed forward bodily for some distance, the bedding assuming the most fantastic appearance" (166, 167). Several drawings are given illustrating these displacements.

"In many places the beds are confusedly twisted, crumpled, and contorted—the laminæ being bent violently over, now in one direction, now in another" (266). "Rock-basins occur in regions where the strata are "bent and contorted in a hundred curves all along and under the length of the lake, nor does the direction or slope of the basins bear any relation whatever to the prevailing inclination of the strata" (288). The *faults*, or dislocations, in coal-seams, are of similar import, proving that some force has been exerted to break their continuance. The professor says they extend to from twenty to sixty fathoms, measuring, I presume, in depth from the earth's surface. "They frequently cross and shift each other; yet no yawning crack or irregular depression at the surface gives one any indication of their existence. . . . My impression is that none of these dislocations ever showed at the surface. . . . I may state that, as a general rule, faults increase in extent downwards, and diminish upwards, so that the upper seams are not dislocated to the same extent as the lower seams of the same coalfield." (289.) "During these great oscillations of climate there were not infrequent shiftings in the distribution of land and sea." (506). "The deposits of silt, clay, sand, and gravel, with land-plants and mammalian remains, and occasionally with marine shells, all of which beds are intercalated in the till, clearly show that the intense arctic cold which covered the country with an ice-sheet was interrupted, not once only, but several times, by long continuous ages of milder conditions. Some of these periods may have been warmer than others, just as some of the glacial periods may have been colder. The sea-shells, got in one place at a height of 512 feet in an intercalated bed, indicate that there was at least one period of considerable depression during the accumulation of the Lower Drift" (351, 352). Scotland "became submerged to a depth in the south-east and west midland districts of probably as much as 1100 or 1280 feet. Whether this great submergence extended over all Scotland we cannot yet say." (353). "The land continued to be upheaved, and several pauses in the movement of elevation were marked by the formation of what are termed raised beaches. With the exception of those at the lower levels, all the raised beaches belong to the glacial epoch,

Britain became continental by the conversion of the German Ocean into dry land. At first, probably, bare and treeless, it eventually passed into the condition of a great forest-land. The climate was continental, and the fauna temperate and cold-temperate. Men who used polished stone implements then lived in Scotland. Submergence once more ensued. The destruction of the forest-lands and the increase of peat mosses dated its commencement from this period. Climate insular, but colder than at present. Final re-elevation and formation of the low-level raised beaches" (354). "A large portion of the British Islands, and Scandinavia, sank down below the sea, and Denmark, Holland, the plains of Germany, and northern Russia, also disappeared below the waves" (492). The author figures man as having "entered Britain at a time when our country was joined to Europe across the bed of the German Ocean; at a time when the winters were severe enough to freeze over the rivers in the south of England; at a time when glaciers nestled in our upland and mountain valleys, and the arctic mammalia occupied the land. He lived here long enough to witness a complete change of climate—to see the arctic mammalia vanish from England, and the hippopotamus and its congeners take their place. At a later date, and while a mild and genial climate still continued, he beheld the sea slowly gain upon the land, until, little by little, step by step, a large portion of our country was submerged—a submergence which, as we know, reached in Wales to the extent of some 2000 feet or thereabout. We know further, that, simultaneously with the partial drowning of the British Islands, a vast area in northern Europe also sank down below the waves" (507, 508). Another great change ensued. Those mysterious forces by which the solid crust of the globe is elevated and depressed, now again began to act—the sea gradually retreated, and our hills and valleys eventually re-appeared. Step by step the British Islands rose out of the waters, until, for the last time, they became united to the continent. . . . As years rolled on the sea again stole in between our islands and the continent, until a final severance was effected" (509, 510).

The traces of the climatic changes which the earth has undergone are on a scale to make it apparent that vast ages

were occupied in effecting these transitions. "The disappearance of a *mer de glace*, which in the lowlands of Scotland attained a thickness of nearer 3000 ft. than 2000 ft., could only be effected by a very considerable change of climate. Nor, when one fully considers all sides of the question, does it appear unreasonable to infer that the comparatively mild and genial periods, of which the inter-glacial beds are memorials, may have endured as long as those arctic or glacial conditions which preceded and followed them. We have a difficulty in conceiving of the length of time implied in the gradual increase of that cold which, as the years went by, eventually buried the whole country underneath one vast *mer de glace*. Nor can we form any proper conception of how long a time was needed to bring about that other change of climate, under the influence of which, slowly and imperceptibly, this immense sheet of frost melted away from the lowlands and retired to the mountain recesses. We must allow that long ages elapsed before the warmth became such as to induce plants and animals to clothe and people the land. How vast a time, also, must have passed away ere the warmth reached its climax, and the temperature again began to cool down! How slowly, step by step, the ice must have crept out from the mountain-fastnesses, chilling the air, and forcing fauna and flora to retire before it; and what a long succession of years must have come and gone before the ice-sheet once more wrapped up the hills, obliterated the valleys, and, streaming out from the shore, usurped the bed of the shallow seas that flowed around our island! Finally, when we consider that such a succession of changes happened not once only, but again and again, we cannot fail to have some faint appreciation of the lapse of time required for the accumulation of the till and the inter-glacial deposits" (199-201; see also 405, 406).

Professor Geikie thereupon puts before him the problem to be solved. "If we find," he observes, "the remains of full-grown trees in Greenland, and ammonites and corals even farther north, we may be quite sure, that, owing to some cause, apparent or obscure, these regions must at one time have received from some external source a greater proportion of heat, either directly or indirectly, than they do now. And

so, conversely, if in our own land we discover traces of great snow-fields and massive glaciers, we cannot hesitate to conclude, that in the ages when such frigid conditions prevailed, this area was deprived of much of the heat which now reaches it. But if this be so, we may well ask what the nature of that action is which can alternately visit our hemisphere with long continued ages of fruitful summer, or render it bleak and barren with perpetual snow and ice" (106, 107).

Disposing of Sir Charles Lyell's opinion that alterations in the distribution of sea and land may have produced the changes of climature that have occurred, as insufficient for the purpose, the author rightly concludes that the proper quarter to which to look for the required solution is the relations of our planet to the sun (121), the indubitable ruler of all our great climatic variations. It would have been well, and only in keeping with the principle he had apparently laid down, that like causes should be suggested for like effects, had the professor, in selecting the agency of the sun to account for the phenomena before him, applied that agency in the manner it is seen to operate, to our habitual experience, in raising or lowering the temperature of the earth's surfaces. This, however, he has not done. Restricting himself to the measure of knowledge imparted to us by the astronomers, and supporting himself with Mr Croll's views, he can see no altering conditions of the earth, relatively to the sun, to which to attribute the climatic changes that are in question, than the deflection of the poles of the earth in that circular gyration which causes the precession of the equinoxes, and the variation in the form of its ellipticity which the orbit of the earth undergoes through the attractions the earth experiences in its path from other planets (124, 134, 135, 149, 507).

The measures of these two movements are very diverse, and it appears hard to understand how they are to enter into combination with one another, in order to effect, at stated times, between them, the same periodical results. The equinoctial rotation the professor limits, in round numbers, to 21,000 years, by making allowance "for another complex movement, due to the action of the planets" (130), referring,

I presume, to that known as the revolution of the apsides (Denison, *Astronomy without Mathematics*, 31). The orbital movement he has not computed. The diameter of the ellipse is held to vary by 13½ millions of miles. We are thought to be at present eleven millions of miles short of the extent to which the ellipse may be contracted, and for this 210,065 years are said to be requisite (Lyell, *Prin. of Geo. I.* 292, depending on a calculation by Mr Stone of the Greenwich Observatory). The entire movement, calculating on this scale, would occupy 257,805 years, and the period between each extreme of heat and cold for the earth would be the time during which the orbit was reaching its extremes and returning to the same point again, or 515,610 years. To bring the very much shorter period of the precessional rotation into combination with this vast period, so as to attribute to the two some given long sustained joint results, appears therefore an unreasonable proposition. Had either movement sufficed for the professor's purposes, he would scarcely have resorted to the embarrassing proposition that the two were bringing them about together.

It may be conceded that the divergence of the poles in the precessional rotation has some effect upon the climature of the earth, but this can only be within degrees not reaching to the limits of the changes before us. To produce transitions from arctic cold to tropical heat, and to maintain the altering condition over long ages, obviously requires some far greater and more persistent causation. This the professor seeks in introducing the variation in the orbit as an inducing cause. But he does so without evidence that the movement has such results. The true course in judging of the operations of nature is to follow ever in her own footsteps. We ought to be satisfied that whatever the circumstances which have produced the ice that covers the polar regions, so occupying them over a very lengthened course of years, they are just those that must have prevailed when the temperate regions were covered over with an equally thick and enduring similar coating. We should be in like manner satisfied that whatever induces the torrid climates of the equatorial regions which are seen to be necessary to the existence of the elephant, tiger, lion, rhinoceros, and hippopotamus, the same

must have brought about the like climate in the temperate quarters when they were the habitat of these animals. There is nothing we know of which regulates these very differing climates but propinquity to the poles, with reception of the rays of the sun in a very oblique direction, or not at all, and distance from the poles, with the reception of the rays in their fullest power vertically. Professor Geikie, however, resorts to a cause for these phenomena, not only unsupplied to him by any experience before us, but running counter to such indications as we do possess. The earth's distance from the sun in the course of its orbit, he presumes may mainly bring about the recorded extremes of climate under which Great Britain has at one time possessed the icy temperature of Greenland, and at another the torrid heat of India or Central Africa. In the course of our current annual circuit round the sun, we pass at times nearer and further from him, as he is not situated centrically to our orbit; but it happens that when we are nearest to him, it is with us mid-winter, and when furthest from him, it is mid-summer (Guillemin, 121), so that the professor has to make the admission, adversely to his theory, "that mere proximity to the sun will not necessarily produce a warm season" (139).

This is also otherwise demonstrable. A condition on which the transmission of heat from the sun's rays absolutely depends, is the atmosphere surrounding our globe. At low levels this atmosphere is dense, and the heat is conveyed in potency; at high levels it is rarified, and the access of heat is proportionately reduced. The effect of distance from the sun, as here judged of, is to induce heat, and of propinquity to him, cold. We have snow and ice maintained continuously at all seasons of the year on the Himalaya and the Andes, and subtropical and tropical climates occurring on the low grounds at their bases. It must then follow that to remove us in distance from the sun, or to bring us nearer to him, in spaces devoid, or nearly so, of a conducting atmosphere, in the measures involved by the variation of the orbit, would not cause sensible changes of climate, far less effect the excessive changes which are in question.

Of the circumstance that the tropics must have been under a coating of ice as thick and permanent as that which now covers Greenland, the professor is evidently unaware. His explanation of the passage of the erratic boulders will alone account for those seen strewn upon the plains of India. "The boulders in Mysore, &c.," my correspondent writes to me, "are in some places piled one on the top of another in thousands, and their size is from ten to twenty feet thick. Near Chittoor I saw them scattered over a grassy plain extending for many miles, exactly as if they had been deposited by melting ice, as no doubt they were." We have to figure to ourselves ice covering these regions to a thickness of thousands of feet, the western range of mountains, running to elevations of four and five thousand feet, and in one part, namely at the Neilgherries, to over eight thousand, remaining uncovered, and it becomes quite intelligible that the boulders in question have been splintered off these heights by the intense frost, and borne on the ice eastwards and westwards to where they have been discerned. The foot of the Neilgherries approaches within forty miles of the western ocean, just where the huge boulders forming the Sacrifice Rocks, eight miles out at sea, occur. And on the other side the hillock, near Madras, named St Thomas's Mount, has arrested the passage of numbers of these erratics on their way to the eastern ocean. The professor's theory of course does not cover this condition of things within the tropics. The presence of tropical and sub-tropical vegetable and animal remains in the arctic regions forces him to allow of the transference of tropical heat to those quarters, but he has no consciousness that this entailed the corresponding transference of arctic cold to the tropics.

The contortions of strata met with, the professor thinks, may have been caused by the grounding of icebergs and the passage of ice otherwise over the stratified beds (267), but so partial a cause does not suffice to account for a result I understand to be altogether general. We everywhere observe seriously disturbed strata, and it is not to be supposed that the moving masses of ice have equally been everywhere. For the greater and more decided action which has fractured the coal-seams, the more extensively the deeper down we go, and

for the very serious upheavals and depressions which have continually altered the earth's levels, he appears to have no explanation to give. These are disturbances evidently to be associated together, and we see such in actual operation in equatorial countries. The centrifugal force there exerted distends the diameter of the earth, and as each portion of the globe may be brought to the position of the equator, it would be necessarily there subjected to the propulsion in that direction continually being effected.

I cannot take leave of Professor Geikie's work without expressing the obligations under which all interested in these questions have been laid by the copious and carefully stated evidence he has produced, from his own actual observations and other reliable sources, to exhibit to us somewhat of the past history of the globe we inhabit. We must rise with [illegible]der from the contemplation of the vast operations of wh[illegible] [illegible] earth is the constant scene. The ancient Aryans, [illegible] from what source of information open to them it is difficult to judge, have pictured to themselves constant dissolutions and re-creations, occupying lengthened ages; and we, in modern times, discern the unmistakeable traces of the like passage of events. The ice prevails and obliterates, or expels, all organized forms, vegetable and animal. The genial rays of the sun return, and all teems again with life. Some few of the animal forms may pass and re-pass, migrating when the climate became unbearable to them, and returning as it ameliorated, and some seeds may have been carried to and fro, and in this manner have perpetuated themselves. But there are multitudes in each kingdom which cannot thus have survived and evaded the pressure of the climate unfavourable to them. The cold would numb and congeal, and the heat would scorch out the vitality of all that were not in a condition so to transfer themselves. The rule in every region is an appropriate *flora* and *fauna*, inevitably, and the presumption must be strong that the productive powers of nature, in each place, raise up and stock it with all the forms of life suitable to it. When we wish to revive the fertility of arable land, we leave it to nurse and restore its energies unused as fallow. The ice age, wherein the processes of vital creation are sus-

pended, may possibly operate as a fallow period, after which nature, released for action, with accumulated forces, may have capacity to launch into life the superior forms, after the manner in which, in ordinary times, she is seen to bring into being the infusoria. To unlock her mysteries our course should be to suggest no other methods than such as she has herself put before us.

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